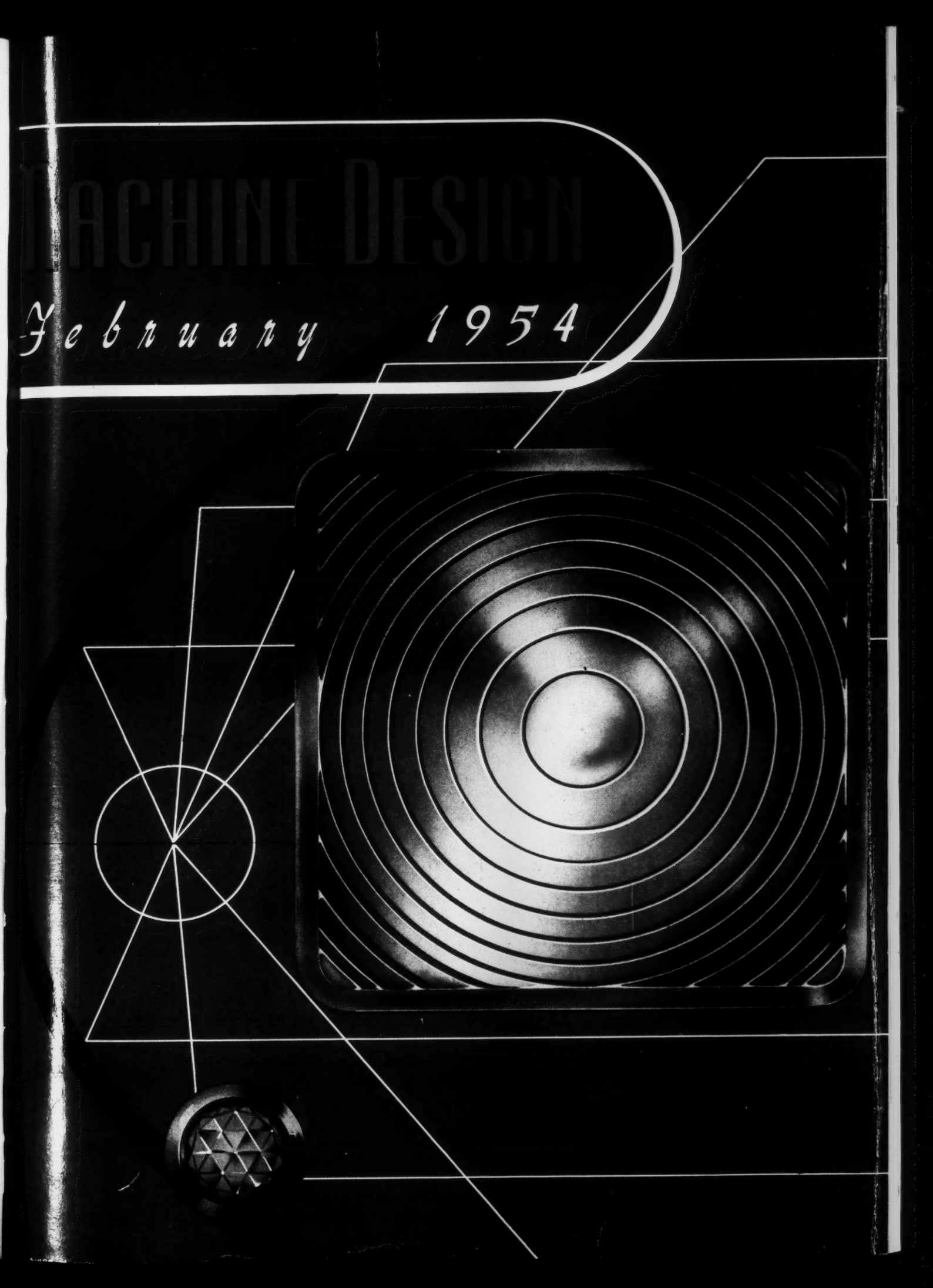
MACHINE DESIGN

February 1954



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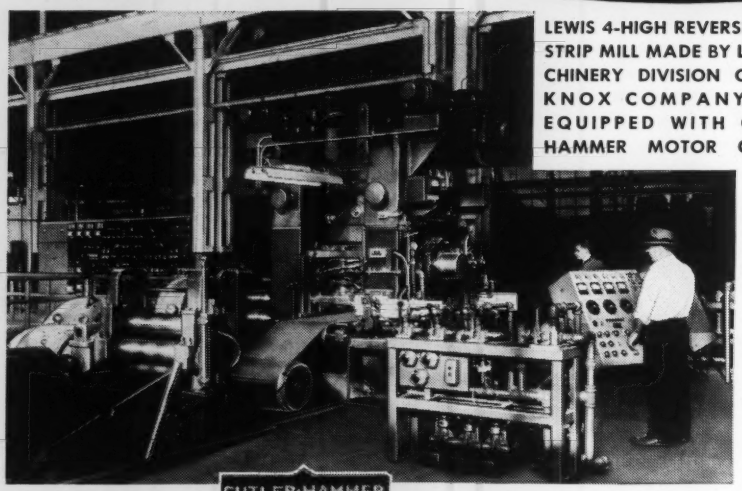

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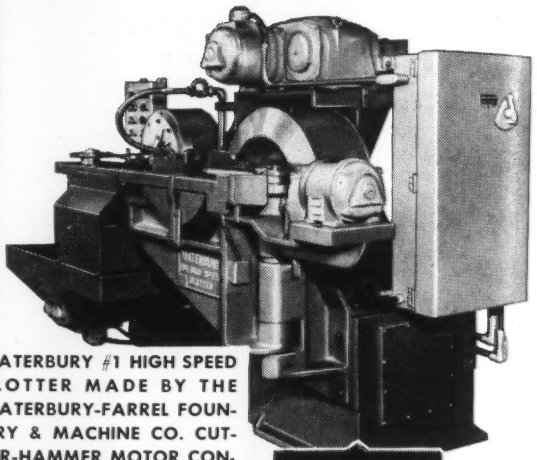

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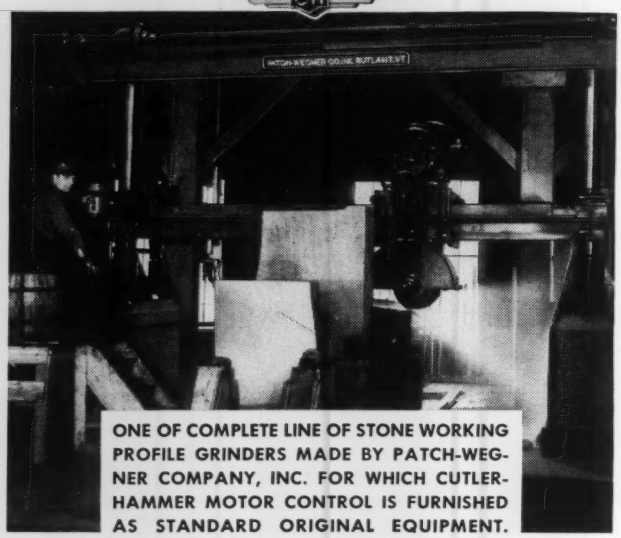

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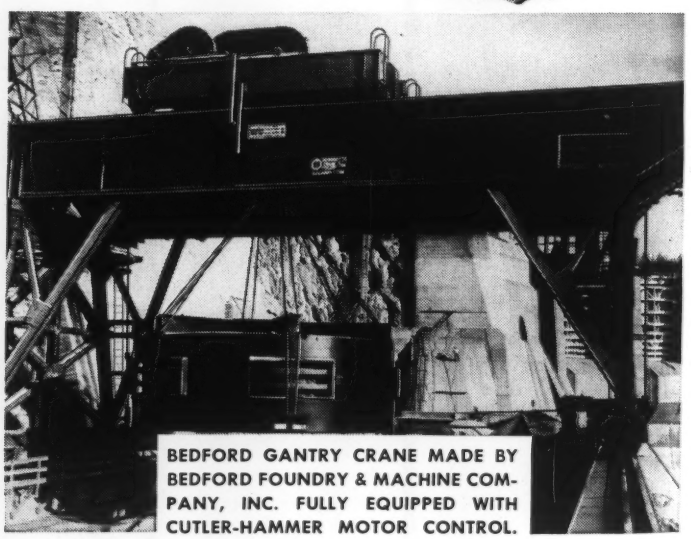

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There is no such thing as a *bad* product of any kind on the American market; competition is too severe for a poor product to exist. But there *are* degrees of merit. Some products are recognized as better than other products. And some few in every field are widely accepted as the *best*. Their makers are acknowledged leaders and their names have become buy-words for assured satisfaction. This position of commercial advantage is neither easily won nor held without a policy of scrupulous attention to every detail influencing product performance in the user's hands. In accepting this obvious fact no thinking person can fail to be moved by the force of the evidence that Cutler-Hammer Motor Control is so frequently and continuously the choice of the nation's leading machinery manufacturers. You too will find it pays to insist on Cutler-Hammer Motor Control . . . . . CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Limited, Toronto, Ontario.

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MACHINE DESIGN

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Over the Board

Practical or Theoretical?

Apparently the First Conference on Mechanisms held jointly last October by MACHINE DESIGN and Purdue was a howling success—at least respondents to a survey of the people in attendance thought so unanimously. A query on the type of program desired for the next conference brings out the interesting fact that most are in favor of a program equally divided between the theoretical and practical aspects of mechanisms; about 55 per cent showed equal interest. About 35 per cent were in favor of a "mostly practical" program, and 10 per cent in favor of a "mostly theoretical" one. We suspect that the figures would be roughly the same for most phases of design. Some of the suggestions made will undoubtedly be incorporated into this year's program and, we hope, will make it even better than last year's.

This Month's Cover

Apropos of the parabolic reflector, Fresnel lens and indicator jewel shown on the cover to highlight Bob Rodgers' article on machine lighting, Page 147, we were rather intrigued by a discussion at a recent SAE meeting about—and note this — hydraulic headlights. George W. Lewis of Electric Auto-Lite Co. had just cited the many places where hydraulic power is used in automobiles. One canny listener popped up with a very pertinent comment. Hydraulic power may be used for many accessories, he said, but it's impossible to replace electric power in at least one place—automobile headlights. Well, said Mr. Lewis (more in jest than in earnest, we hasten to add), we've already considered the possibilities and have come up with one solution. You drill a tiny hole in the filament of the headlight lamp, then force silicone fluid through it at 3000 psi. Result: light. When the method becomes practical, Mr. Lewis continued, we might have to consider changing our company name to Hydraulic Auto-Lite Co.

Fits and Limits

For many years the pros and cons of standards of fits, limits and tolerances have been hotly debated. Although several have appeared in tentative form, none has been finally adopted in this country. Today, a new one—the *ABC System of Limits and Fits,* the American, British, Canadian system based on the older ISO standard—is proposed as an ASA standard for review and comment. Next month, to attempt to air the engineering attitude towards this and other fits and limits standards, we plan to publish a symposium of articles by prominent engineers on the standardization problem in this area of design. We think you'll find it valuable in revealing many of the economic and practical aspects of standardization of limits and fits. And we hope by focusing attention on this vital area some real forward steps will be initiated.

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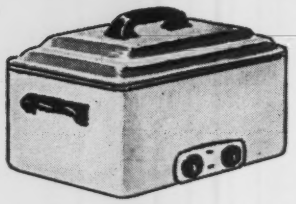

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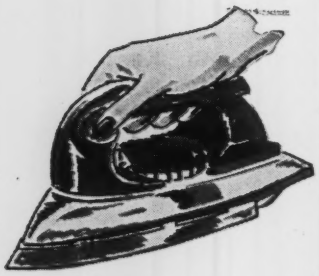
TYPE R thermostats give clean, positive make and break of circuit. Also used in range warming compartments, low-wattage water heaters, and electronic devices requiring a high degree of temperature control.



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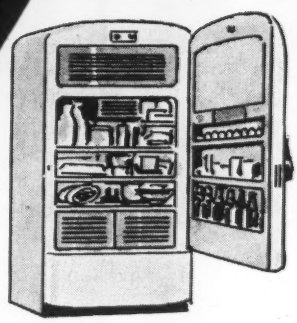
TYPE S thermostats feature clean, positive make and break. Electrically independent bimetal prevents artificial cycling for longer thermostat life. Available in adjustable and non-adjustable styles precalibrated for your product.

STEVENS

STEVENS thermostats make appliances perform better—longer



REFRIGERATORS

TYPE W thermostats give *snap-ac* make or break on temperature rise. W widely in butter-warming compartme electronic devices, rectifier fans, a apparatus requiring sensitive, pre control of high-wattage heater lo

PERCOLATORS

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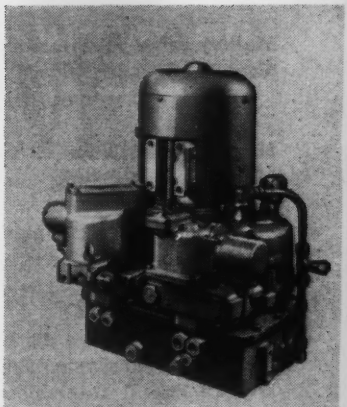

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OILGEAR

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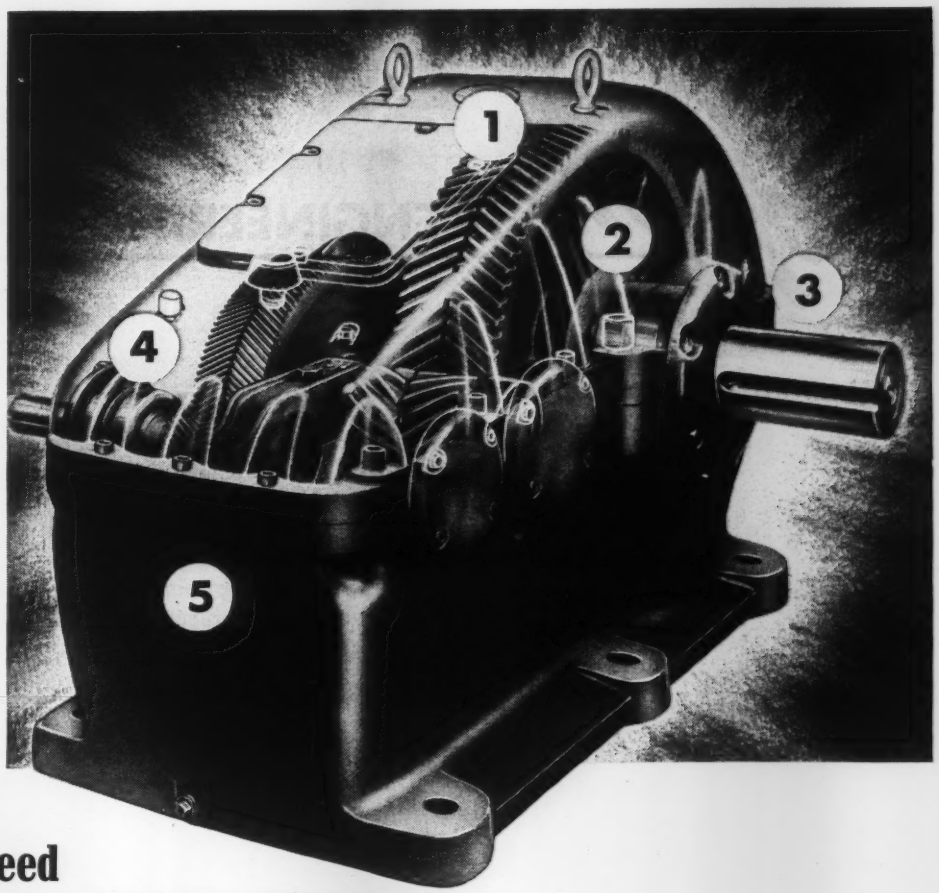
5. **STURDY HOUSING** is designed so all parts can be removed without disturbing base, which can be grouted in concrete.



When you need high-hp speed reduction with heavy shock loads, Link-Belt gives you

everything you want in PARALLEL SHAFT DRIVES

BECAUSE they withstand heavy shock loads, Link-Belt parallel shaft drives are the low-cost answer for many high-hp speed reduction problems. Simultaneous engagement of several teeth assures smooth operation and great load carrying capacity.

What's more, the elimination of power-wasting vibration results in sharply reduced power consumption. Other benefits include quiet operation and increased efficiency.

Link-Belt parallel shaft drives are available in 2.84:1 to 318:1 reduction ratios, ½ to 1000 hp, 2 to 600 output shaft rpm. Ask for Book 2519.

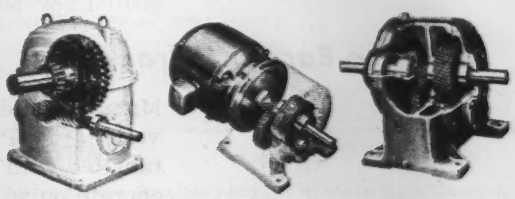
LINK-BELT

ENCLOSED GEAR DRIVES 13,408

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

WHY PRE-INTEGRATED LINK-BELT DRIVES CUT YOUR POWER TRANSMISSION COSTS

In addition to all three types of speed reducers, Link-Belt builds variable speed drives, fluid drives, chains, sprockets, couplings, bearings, shafting. All are pre-engineered for easy installation and maximum efficiency.



Worm Gear Drives — ask for Book 2324-A

Gearmotors — ask for Book 2247

Helical Gear Drives — ask for Book 2451

MACHINE DESIGN

Topics ...IN ENGINEERING AND RESEARCH

Casting of Titanium Nearing Solution

Small ceramic-mold castings of commercial titanium alloys may be possible in the near future. High reaction rate between molten titanium and investment materials contaminates the alloy; however, results on castings produced by Alloy Precision Castings Co. by the frozen-mercury pattern Mercast process are said to be "encouraging." So far, main attempts have been laboratory experiments on an aircraft latch. Production will be limited, however, by present nonavailability of satisfactory melting equipment and production-quantity procedures.

Ages 30 to 35 Are Peak Years for Inventors

Inventions are most likely to come from men 30 to 35 years of age, according to Harvey C. Lehman as quoted in Arthur D. Little Inc.'s *Industrial Bulletin.* Based on a study for his book, *Age and Achievement,* Dr. Lehman's conclusions are that valuable work is produced by a creative thinker during most of his life and creativity declines slowly; nevertheless, the peak comes early. Even Edison, who was active until has eighties, received 28 per cent of his patents between ages 33 to 36. Some other "peak" years are: mathematicians, 35 to 40, and chemists, 30 to 34, with most great chemical advances announced by men from 26 to 30. "Leaders," rather than "creators" reach peaks later in life: cases cited are college presidents, 50 to 54, and U. S. senators, 60 to 64.

Vibration Miner Shakes Coal Loose

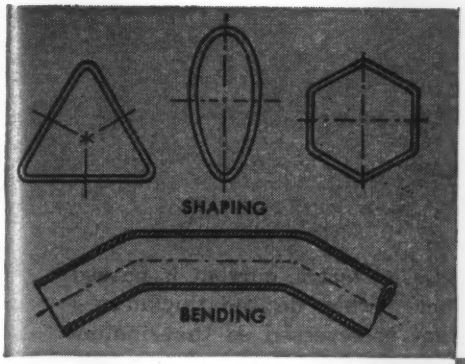
A novel kind of coal-mining machine literally shakes coal loose by hammering it at just the right frequency. The Konnerth machine developed at U. S. Steel tumbles down coal by holding two hammers against the vein face and vibrating them at the critical coal-seam frequency—30 cps for many soft-coal seams. Each hammer, Westinghouse powered, is connected to one phase of a two-phase, 30-cycle, 30-kilowatt generator mounted on a truck for mobility.

Tiny Balloons Stop Oil Loss

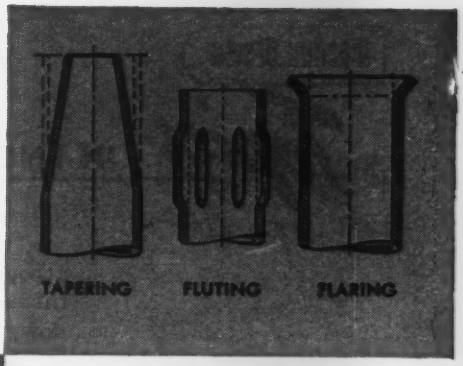
Evaporation of oil in storage tanks can be reduced 80 to 90 per cent by tiny plastic balloons which form a floating "cover." The balloons—called Microballoons by Standard Oil of Ohio who developed them—are actually tiny bubbles of Bakelite phenolic plastic 0.0002 to 0.0036-inch in diameter and filled with inert nitrogen gas. In tests, the Microballoon foam has floated for more than two years without deterioration.

"Surface-Barrier" Transistors Operate at High Frequencies

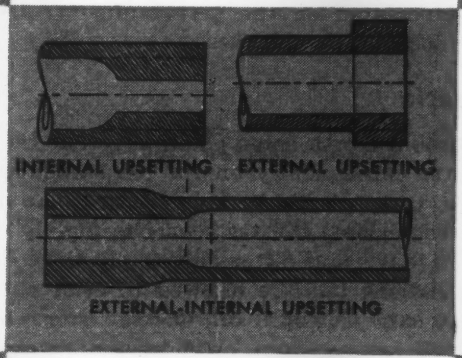
Manufactured by a unique method, new "Surface-Barrier" transistors developed by Philco operate at frequencies 10 to 100 times as high as obtainable with older alloy-junction transistors. Additionally, the new units operate on so little power that a portable military communications receiver as small as a pack of cigarettes and powered solely by two flashlight cells is said to be entirely practical in frequency ranges up to 70 megacycles. Production control and mechanical precision of the manufacturing process are very high. Two tiny streams of liquid indium salt are directed



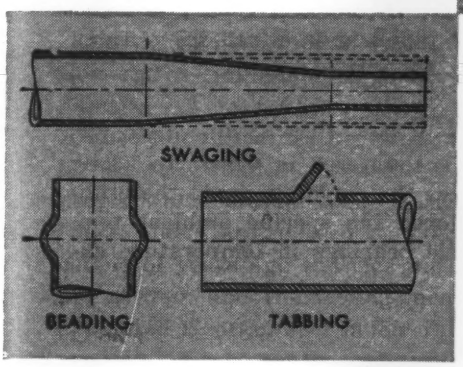
OSTUCO TUBING is versatile!



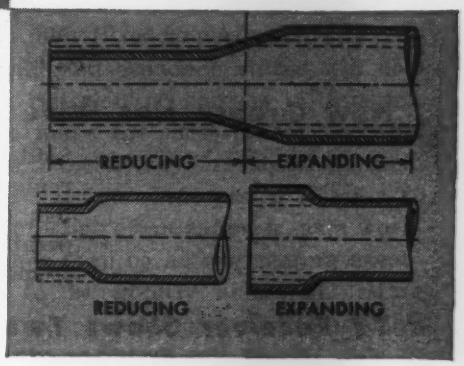
OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!



you draw the blueprint . . . we'll deliver the goods

There's practically no limit to the things OSTUCO can do with Seamless and Electric Welded Steel Tubing to help you produce lighter, stronger, better looking products at lower cost. Only a few of the operations are shown above.

Newly expanded and modernized facilities for *manufacturing, forging,* and *fabricating* tubing, all in one plant — plus our own steel source as a member of the Copperweld family —speed deliveries, assure highest quality and save you money.

Tubing is our business, not a side line. OSTUCO's unique "Single Source" operation, with unified production control, eliminates shipments from one location to another . . . greatly reduces rejects . . . prevents errors . . . puts an end to buck passing and red tape. You write one order, get one bill, and responsibility is clearly fixed. Write for informative catalog, "Ostuco Tubing."

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company
Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing
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EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY, 117 Liberty Street, New York 6, N. Y.

at opposite sides of a tiny slab of germanium. Electric current is passed through the streams to etch the germanium. When desired thickness—down to 0.0001-inch—is reached, the current is reversed so that indium is electroplated on the germanium. Tolerances of 0.00001-inch are said to be possible on thickness.

Rats Feed On Tasty Plastic

One problem with some plastics is that they prove unusually appetizing to rodents; consequently one of the standard tests is to serve a meal of delicious, tasty plastic to hungry rats. As described by Minneapolis-Honeywell technicians, the test consists merely of giving two rats one good rat meal a day, plus after-dinner plastic to gnaw on. Two other rats get short rations but are allowed to stuff themselves on all the plastic they care to eat. To top it off, one rat from each group dines in style—he gets his food served right on a plastic "plate." If the rats turn gourmand and show a proclivity for plastic, a nasty repellent is mixed in—a ratty trick on the rats.

New Grease Has Wide Temperature Range

Said to be effective in climatic extremes encountered in desert to arctic regions, a new grease developed by the Texas Co. could eliminate the problem of handling and storing greases tailored for specific ambient temperatures. The grease can lubricate vehicle bearings in temperature extremes ranging from −65 to 125 F.

TV Receiver Shows Two Pictures on Same Screen

Two television programs can be shown simultaneously to the same audience on the same screen with the new Duoscopic receiver announced by Allen B. Du Mont Laboratories Inc. Polaroid glasses are used to separate the two polarized pictures; either program can be viewed merely by reversing the glasses. Individual earpieces and remote-controlled audio units enable each viewer to hear either channel.

Largest Rotating Electric Machines Ever Built

Generators for the McNary Dam will be the largest rotating electrical machines ever built. Thrust bearings which will support the generator and hydraulic turbine will carry a load of 4 million pounds. Contracts for the equipment have already been awarded by the U. S. government to the English Electric Co., although General Electric, lowest domestic bidder, is contesting the award.

Delayed-Action Switch Keeps Auto Lights On

To light a driver's path after he leaves his car, a delayed action switch produced by Edco International Inc. keeps the headlights, parking lights or taillight on for a maximum of 1½ minutes. Screw adjustment permits the turn-off time to be varied up to the maximum.

Giant Sphere for Atomic Sub Engine Completed

The giant steel sphere at West Mihon, N. Y., which will be used for testing experimental submarine atomic power plants, has been completed. The big globe, designed to shield the surrounding population in the remote event that all the reactor's safety controls fail simultaneously, is 225 feet in diameter and contains 5.4 million cubic feet of free space. Its thick skin is composed of 682 one-inch thick, 6-ton steel plates welded together.

MACHINE DESIGN
FEBRUARY 1954

The Rise and Fall of an Engineer

GEORGE was a brilliant engineer. His designs were characterized by a simplicity and directness of approach which earned the admiration of his more pedestrian colleagues. They were the outcome of a native ability not far short of genius coupled with keenness of perception and a single-minded dedication to the job at hand.

These qualities of the mind were supplemented by a well-rounded personality and a liking for people which prompted his classmates to vote him "most likely to succeed." They were right. A couple of years ago the vice president of engineering retired, and the management of his company appointed George, still in his thirties, to that key position. Last month the president died suddenly and George got the job, having demonstrated that the problems of management were a push-over for his talents.

A success story in the American tradition, you will say. George has achieved a goal which represents the height of ambition for many an aspiring engineer.

But what of that fertile brain, just about limbered up and beginning to acquire some wisdom, experience and judgment to temper the flashes of brilliance? What contributions could that mind make to the advancement of engineering in the next thirty years if only its owner didn't have to shuffle papers behind a desk or sit in conferences all day? George's singleness of purpose will not permit him to divert time and attention away from his present responsibilities. As a result the company—and the nation too—has lost possible engineering ideas, inventions, developments, analyses of untold importance and value while George himself, although by no means unhappy, feels slightly frustrated through a sense of unfulfilled destiny.

But suppose George had not been offered, or had refused, that promotion two years ago? Under present policy, what else could his company have done to reward his efforts by improving his status—prestigewise and salarywise—that would not also have given him supervisory responsibilities tending to distract his mind from the functions which it is so uniquely fitted to perform?

Seemingly social and economic status will continue to be the criterion of success in America. So, if we are to make the most of our potential in engineering and technology, management must accept some startling new concepts in relation to engineers. The prestige of an engineer, as a working engineer rather than as an engineering executive, will have to be greatly enhanced. More startling, management must recognize the principle that some working engineers are worth more to the company than their supervisors, and should pay them accordingly. Indiscriminate advancement of all engineers is neither necessary nor desirable, but outstanding engineering achievement for itself alone can and should merit a status—social and financial—comparable to that of a high company official, quite apart from any supervisory responsibilities.

George is still proud to call himself an engineer. He will probably be elected president of his professional engineering society one day and will acquire a national reputation. The restless urge to apply his mind to tough engineering problems will become submerged in the day-to-day activities of an important man of affairs and he will enjoy his fame and fortune. But our generation will have suffered an irreparable loss of potential engineering achievement which an enlightened management policy could have saved. Must it be ever so?

Colin Carmichael

EDITOR

How to Develop a DRAWING NUMBERING SYSTEM

A good workable drawing, parts and records numbering system is a must. The all-numeric method discussed in this article offers a practical answer regardless of the size of the manufacturing organization

By James F. Foley
Director of Products and Methods Research
Remington Rand Inc.
New York

ONE basic rule governs the structure of any records, parts, or drawing numbering system: whatever the scheme chosen, however it be adapted to particular or unusual circumstances, it must serve the needs of an entire manufacturing operation. From president to stock boy, from design engineer to assembly line foreman, the identification system must be everyone's practical tool for daily work, and be uniformly clear and accurate, *Fig.* 1.

This statement sounds somewhat platitudinous. The truth of the matter is that the establishment of a numbering system is often so complex an undertaking that the easy out is to set one up to fit the needs of a major plant activity, such as inventory and purchasing, and let other departments make the best of the result. Under these circumstances, it is usually only a matter of time before confusion, misinterpretations, and the resulting errors in purchasing, inventory, and intraplant transit of material reach serious proportions.

Every design engineer fully appreciates the role played by compromise in the perfection of a product or process. Ideals, the intractable laws of physics and chemistry, economic factors, and practical considerations must be juggled until the best possible end result has been achieved.

The design of a numbering system is no exception. In setting one up, the natural desire for short, uncomplicated identification numbers must

Fig. 1—A uniformly clear and accurate identification system is a necessary practical tool in economical manufacturing

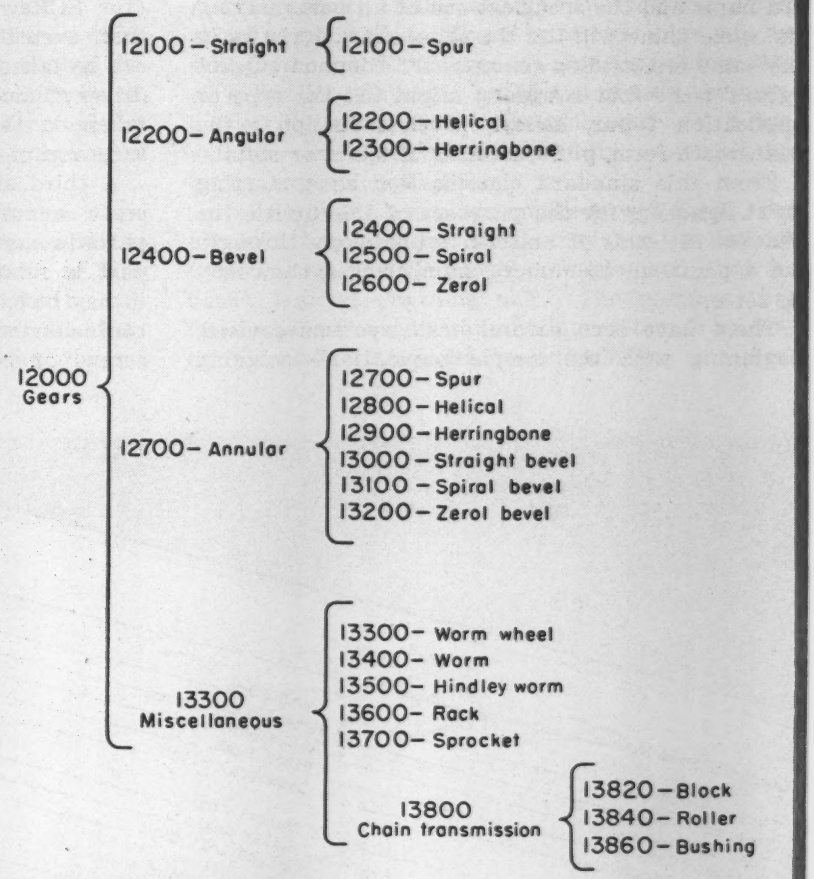


Fig. 2—Example of an all-numeric numbering system breakdown for gears

often be balanced against parts inventories running to a hundred thousand items or better. A numbering key most convenient to production control is not always suited to efficient stockroom procedures.

The advantage of groupings and descriptive subgroupings so that anyone knows immediately that 124576 represents a type of half-inch bolt can be carried only so far, before such weird and clumsy labels as 12-4576-A51-0066-R.1 create absurd tangles, and personnel go back to writing out requisitions reading "One hundred half by six brass bolts to fit the transmission on this year's DeLuxe Coupe!"

Though this example is drawn from the giant structure of automotive manufacture, the same confusions and problems exist in small and middle-size organizations on a lesser scale, but with potentially equally disastrous result to operating efficiency.

Developing the Basic System: What is the answer? Obviously, since circumstances vary radically from one industry to another and even from one similar operation to another, it is not possible to create a reasonably short handbook of numbering techniques that will provide an answer for every detailed situation. However, certain basic principles have acquired validity in the course of time, and provide a sound foundation on which to

build a system.

First of all, standardization of nomenclature and description is an absolute *must*. All parts and basic assemblies, if conditions warrant, of a single generic classification are assigned the same standard name and the specifications of all parts having the same name will list the same characteristics in the same order. For example, the common subject "gears": the first subgroup might list the type or application (spur, helical, bevel, reduction); the next, tooth form, pitch, number of teeth, or metal.

From this standard classification as a starting point, ignoring for the purposes of this article the benefits in terms of uniform terminology throughout a plant, an all-numeric numbering system may be set up.

There have been several basic systems devised, beginning with the simple sequential—assigning numbers serially, starting from 1, to each part as it is added to a manufacturing operation. A more ambitious system, the mnemonic, is in common use but breaks down once large numbers of items become involved. A simple example would be SCR6326 (for SCRew, 6-32, 6 inches long). It is evident that, even if three and four letters are used, SCR can be taken to mean "screw," "screen," or "screwdriver;" moreover, a stockroom order eventually takes on the appearance of alphabet soup when turnover of items becomes sizeable.

A third and specialized system is in use in aircraft manufacture, where the total of individual parts in one finished plane runs to huge figures. A part is related to a particular assembly in which it may be used. This is simple in theory but breeds confusion when a specific size of rivet, machine screw, or ball bearing may be incorporated into

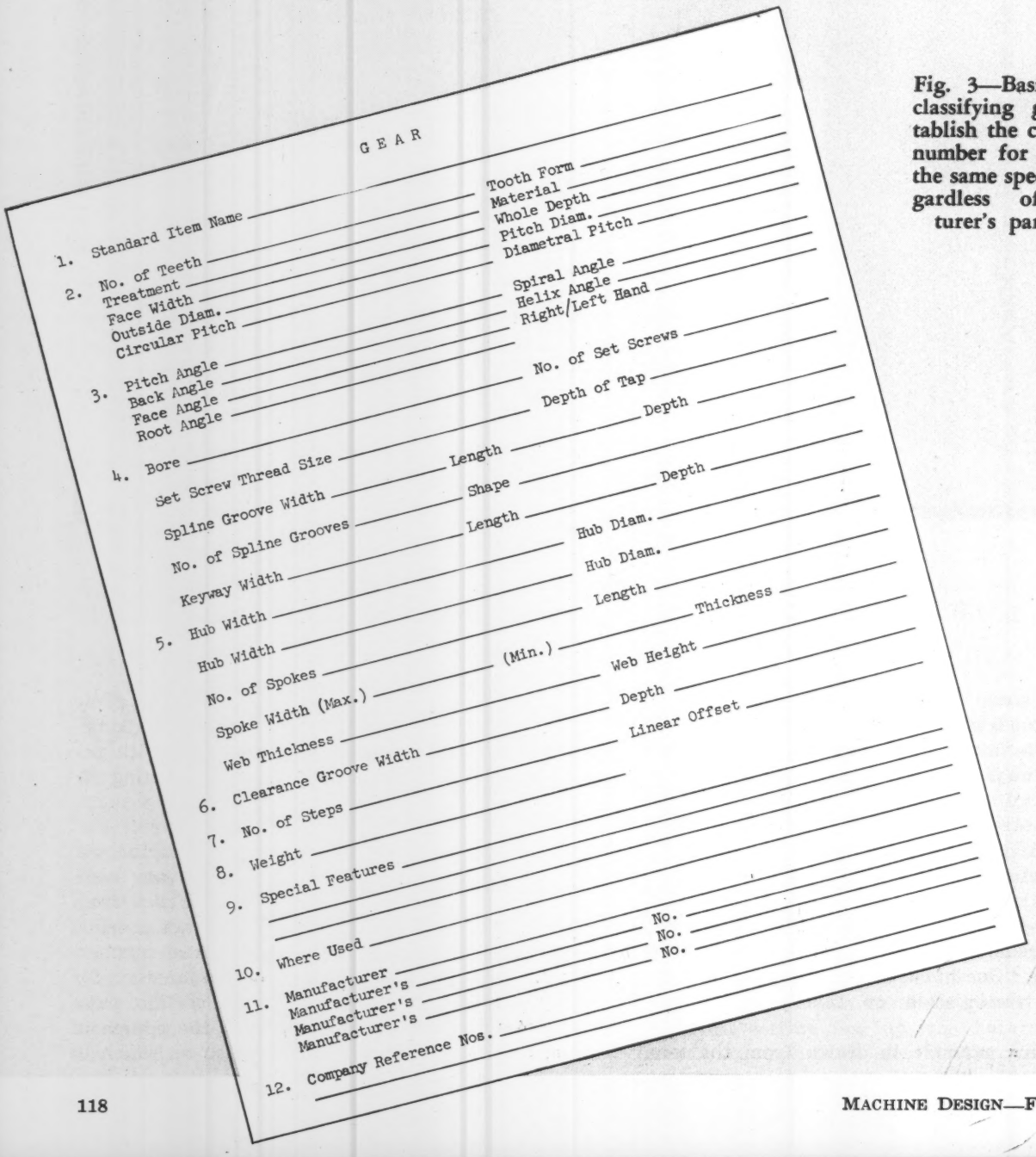


Fig. 3—Basic form for classifying gears to establish the common part number for all gears of the same specification regardless of manufacturer's part number

fifteen different and unrelated assemblies. Identification numbers become very long and complex, an evil tolerated only because it is wholly inevitable, and because the system essentially satisfies the needs of the industry.

An All-Numeric System: The all-numeric system, on the other hand, is not complicated, is flexible, and offers the advantage of ample expansion room while retaining a logical pattern and keeping the length of identification numbers within reasonable bounds.

Starting with a standardized nomenclature classification scheme each major category is assigned a basic number, made as large as the scope of the operation demands. Thus, "gears" might be assigned the 12000 series. The first subclassification, "straight," might run from 12100 on; then "angular"—12200, and "bevel"—12400 and so on, *Fig.* 2.

DRAWING NUMBERING SYSTEM

In the same vein, with angular helical gears starting from 12200, angular herringbone gears would carry 12300. These brief examples will establish the pattern of the all-numeric system, and a particular company's needs will dictate the number of digits required to provide sufficient scope, and the size of the gaps left in the sequences for future expansion, *Fig.* 3.

At this point, many an engineer will insist that his firm has had just such a system in use for years, that it's ridiculously simple, and that he hasn't learned anything new. The point is that the simple all-numeric numbering system is no better than the standardized nomenclature classifica-

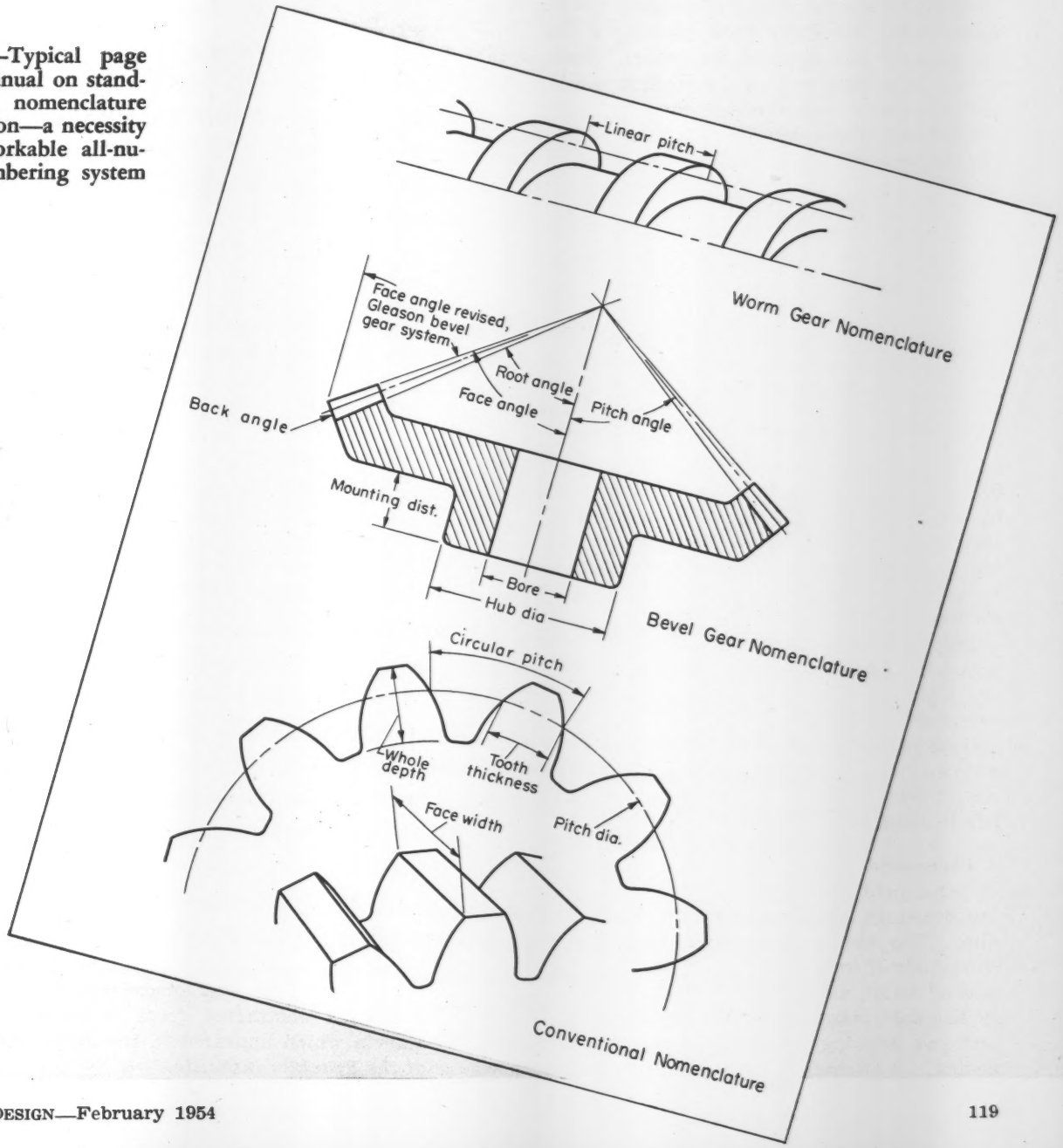


Fig. 4 —Typical page from a manual on standardized nomenclature classification—a necessity for a workable all-numeric numbering system

tion underlying it, *Fig.* 4. To retain good order, and make such a system easily applicable to the needs of every department within a manufacturing organization, that standardization should be performed, agreed upon all around, printed and distributed to all concerned in the form of an operating manual, and strictly enforced—both in observation of existing numbers, and correct assignment of new ones. The theorem has just been stated in one sentence, but the practical application is no small matter.

Beyond the basic principles outlined earlier, a numbering system is governed by the peculiarities of the operation in question. The actual establishment of the system is far from being a one-man job, and the much-maligned, often mishandled committee system is necessary. Representatives covering company policy, research, engineering, production, quality control, maintenance, inventory and purchasing, and possibly sales should work as a team to bring about the basic standardization.

This does not mean setting up a committee that promptly appoints some unfortunate junior member to tackle the dirty work, meeting at the bitter end to hear and applaud his report. Only if the system is worked out as a co-operative plan, with any necessary compromises thrashed out to the satisfaction of the departments concerned, will the system be worth a tinker's dam in terms of error-prevention, smooth operation, and cash savings. In some cases, considerations of time or complexity dictate the retaining of an outside firm of specialists, whose great virtues are the bringing of wider experience to knotty problems, and the installation of a new system without the interruption of normal routines.

The general principles of the all-numeric standard classification system outlined in this article apply equally well to engineering drawing numbering. The soundest plan is to use the same system for parts and drawings, applying the same identification number to a given drawing as is used for the corresponding part or basic assembly. Extra classifications must, of course, be provided for major subassemblies and completed units, and may be integrated with the standardization of nomenclature.

The only supplemental information that need be keyed is the physical size of a print, and the standard alphabetical prefixes in common use should be retained (A, B, C, etc., for common sizes). Revisions, when minor, may be indicated by the traditional "Rev.1" or simply "R.1." but should warrant a new assignment of both part and print number if changes are appreciable.

Permanent Records: More and more the problem of permanent retention of documents and engineering drawings is being solved by the use of microfilm. The ability of modern equipment to cram thousands of images into small rolls of film with no loss of detail, and to do so quickly and inexpensively has sold many firms on periodic filming of record and drawing accumulations as a routine procedure. A 16mm film is generally used for documents, 35mm for prints and drawings. The U. S. Bureau of Standards rates safety film as having a life at least equal to best rag paper, with the advantageous properties of nonself-combustion and slow burning when exposed to naked flame. It is consequently perfectly safe to film old drawings (having them available for much quicker reference than with physical storage systems) and destroy the originals. Duplicate films being housed in such safe places as vaults, there is no need to fear fire or theft.

Though some firms prefer to buy their own equipment, most find that contracting for on-premises filming by companies specializing in microfilming is both satisfactory and economical. In either case, there is no need for a drawing or document to leave its "home" office.

They Say . . .

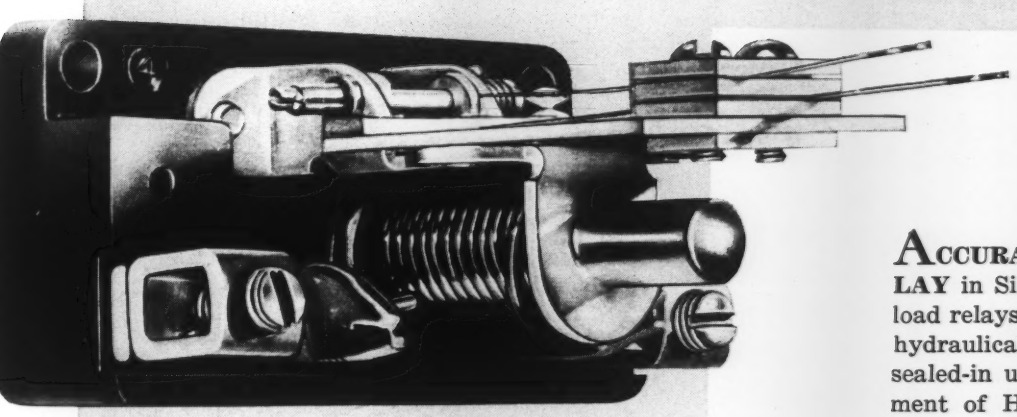
"Anyone who exhibits lack of knowledge of ordinary laws of physics is thrown out of our councils as untrustworthy. If a fellow in our shop talks about increasing the power of a lathe by putting in some gears to increase the horsepower, we recognize that he doesn't know the difference between pounds of force and horsepower. Consequently his chatter is disregarded as that of an ignoramus in that field. But when people, often high in political and even business and academic life, give out opinions on economics, and more particularly on monetary economics, displaying lack of fundamental knowledge or deliberate intellectual dishonesty in those fields, unfortunately they are often listened to gravely without being given a horselaugh or even a skeptical smile. The money illusion can play tricks for a while, but is no more sound than a collection of gears to make a perpetual motion machine."—PHILIP M. MCKENNA, *president, Kennametal Inc.*

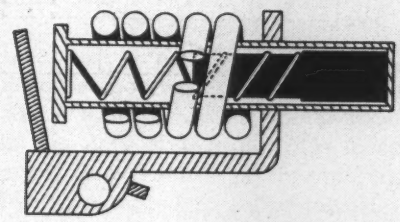
Correction

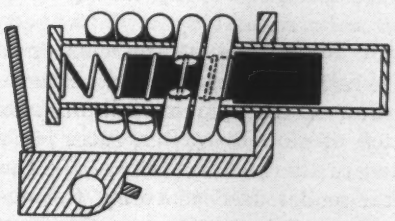
In the article "Designing Electroformed Parts," September, Page 124, the figures opposite *High speed cyanide* under *Copper* in TABLE 2 belong in the corresponding positions opposite *Silver, High concentration, high-speed cyanide.* Rockwell 15W corresponds to the VPN hardness of 60-90.

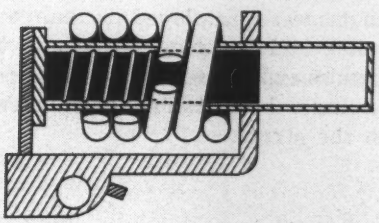
Credit for the item titled "Pivoted-Shoe Bearings for Piston Pumps" (MACHINE DESIGN, Oct., 1953, Page 197) was inadvertently omitted. This item was abstracted from an article by R. H. Marvin which appeared in the July, 1953, *Journal of the Franklin Institute.*

SCANNING the field for IDEAS



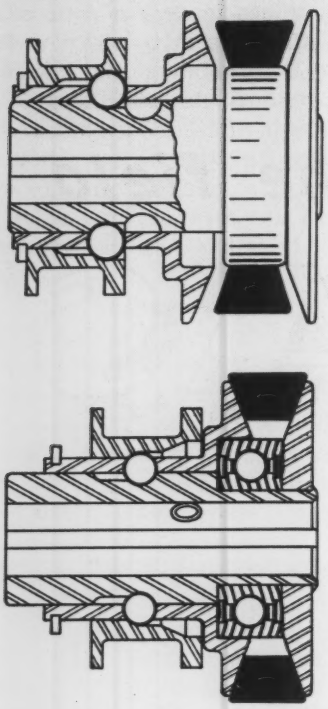




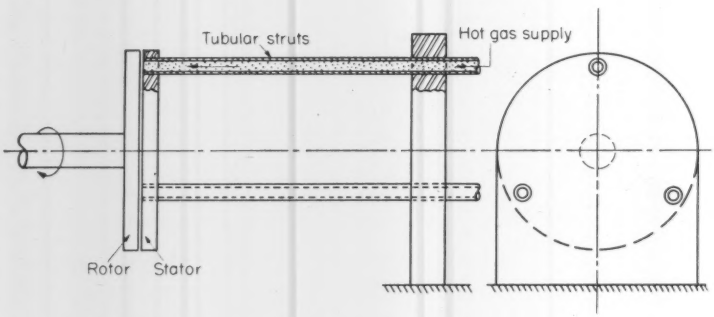


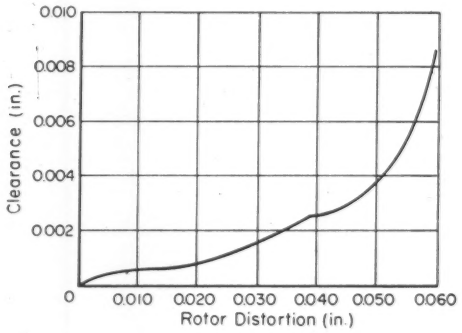
ACCURATE TIME DELAY in Silic-O-Netic overload relays is accomplished hydraulically with a novel sealed-in unit. A development of Heinemann Electric Co., the design eliminates conventional thermal elements and resets immediately as soon as the circuit fault is corrected.

When an overload occurs, a spring-loaded movable iron core in a nonmagnetic tube filled with silicone liquid is actuated by a solenoid coil and travels toward the end of the tube to complete a magnetic circuit for operating the relay armature. Liquid resistance slows down core travel, providing a time delay to prevent nuisance power interruptions due to harmless momentary overloads. Duration of time delay is inversely proportional to the overload current; on high overloads the magnetic force developed actuates the armature before the core reaches the end of the tube.



COMBINATION CLUTCH-PULLEY design developed by V-Belt Clutch Co. offers the advantages of both units in a single mounted assembly. The Ball-lok clutch can be engaged, released, or slipped without interrupting belt motion and has a rated power capacity equal to regular pulleys of the same size. Clutching action is provided by a split pulley having a movable flange controlled through a sliding sleeve. Engagement is facilitated by ball keys which lock the movable flange in position. With the clutch disengaged the belt rides freely on an idler bearing at the bottom of the belt groove. Smooth load pickup and release are provided by the design which can be manual or power operated.





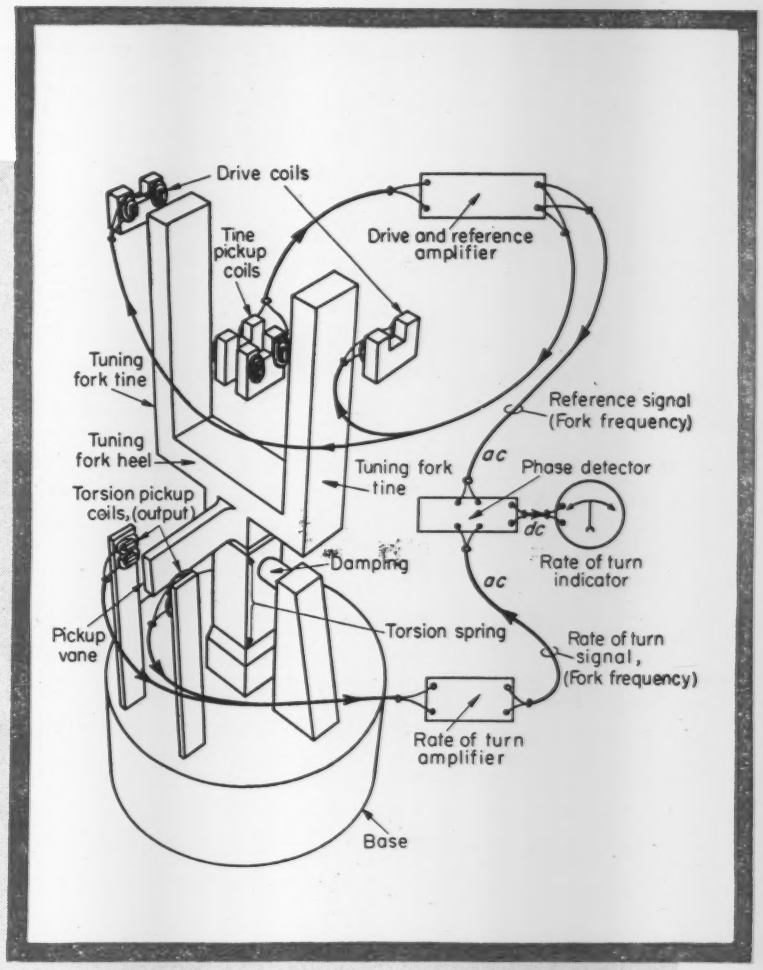
PRECISION CONTROL of running clearance between rotating and stationary machine elements subject to thermal distortion is obtained automatically with a system developed by Professor Arthur Kantrowitz* of Cornell University. Experimental results with rotor and stator disk assemblies indicate that clearances can be readily held to within a few ten thousandths in the presence of distortions running up to 0.035-inch. Corrective motion is applied to the stator disk by the thermal expansion of tubular mounting struts. Temperature of the struts is controlled automatically by hot gas flowing through the tubes at a rate regulated, as in an air gage, by the magnitude of the clearance between the rotor and stator disk. Practical application of the system is limited to compensation of slow distortion rates such as those due to thermal distortion. In the experimental model used to verify the design procedure, three ⅛-inch OD brass tubular struts were employed to support the stator disk and hot gases were used to control the tube expansion. A reverse effect could, of course, be obtained with gases cooler than the struts.

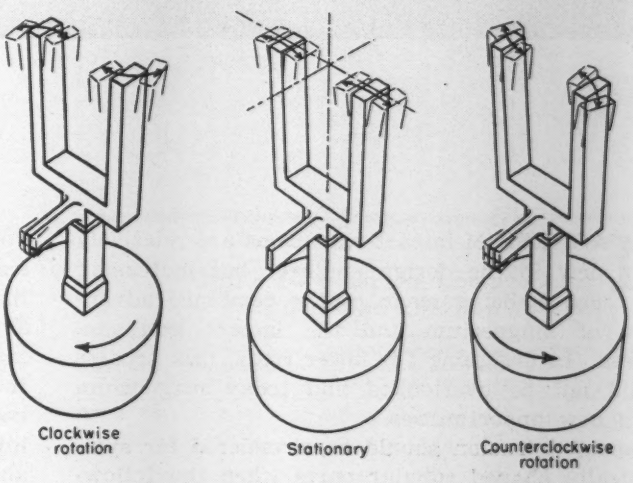
*Complete design details are available upon request.

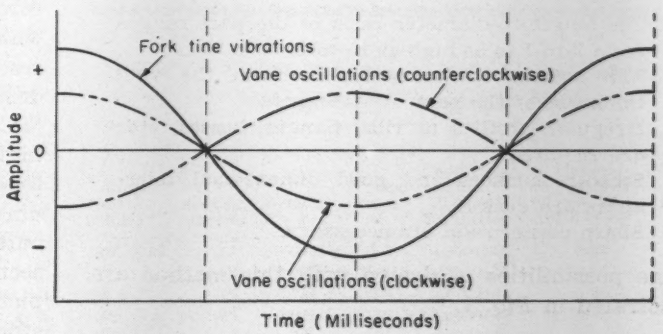
IDEAS

VIBRATIONAL SPEED SENSING in a unique new gyroscope design eliminates troublesome friction effects common to conventional angular-rate gimbal type units and increases stability and sensitivity of response to rate variations. Developed by Sperry Gyroscope Co., the Gyrotron vibratory rate gyro is based on a principle, first discovered by Foucault in 1850, analagous to that used by insects to maintain balance in flight. Sensing element of the device is a continuously vibrating tuning fork. Rotation of the fork body produces torsional oscillations in the heel of the fork which vary in amplitude in response to different rates of turn. Comparison of these oscillations to the vibrations of the tuning fork tines by electrical means provides a reference signal which is an accurate measure of both rate and direction of turn.

In operation, rate of turn is measured by a vane, located at the heel of the fork, which oscillates between two magnetic pickup coils, the oscillation amplitude increasing as the rate of turn increases. Direction of turn is determined from the torsional oscillations and the vibration of the fork tines which differ in phase by 180 degrees for clockwise and counterclockwise rotation. Although still under development, the new design offers a wide variety of possibilities in the field of angular rate measurement. Construction of the unit can be readily adapted to subminiaturization with the smallest ultimate size dependent primarily on manufacturing limitations. Angular rate measurements over a range of one million to one can be achieved with high accuracy and response tines in the order of 0.005-second and less are possible. In addition, the design eliminates the need for bearings and minimizes the number of moving parts, providing a rugged assembly which simplifies maintenance and reduces power requirements.







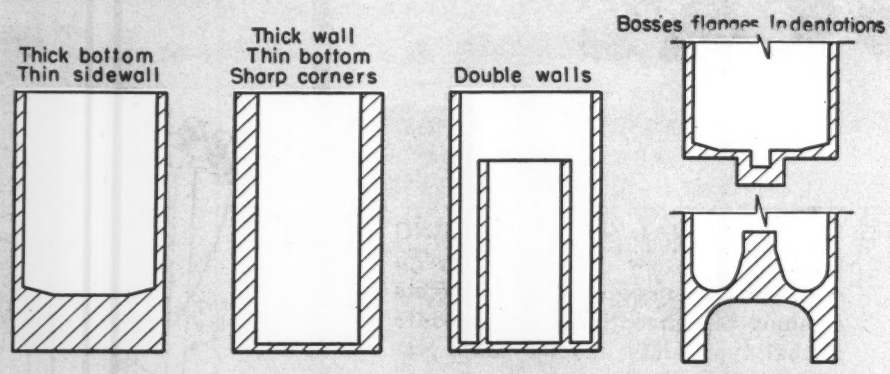


Fig. 1—Group of sections showing some of the design possibilities with impact extruded parts

Designing MAGNESIUM IMPACTS

Today, impact extrusion of magnesium is a practical production method broadening the possibilities of designing for lower cost

By T. L. Patton

Magnesium Department, Dow Chemical Co., Midland, Mich.

MAGNESIUM impact extrusions are relatively new to the design engineer but increasing use is being made of the combined advantages of magnesium and the impact extrusion process. In designing for lower costs, this process should not be overlooked and today magnesium offers new opportunities.

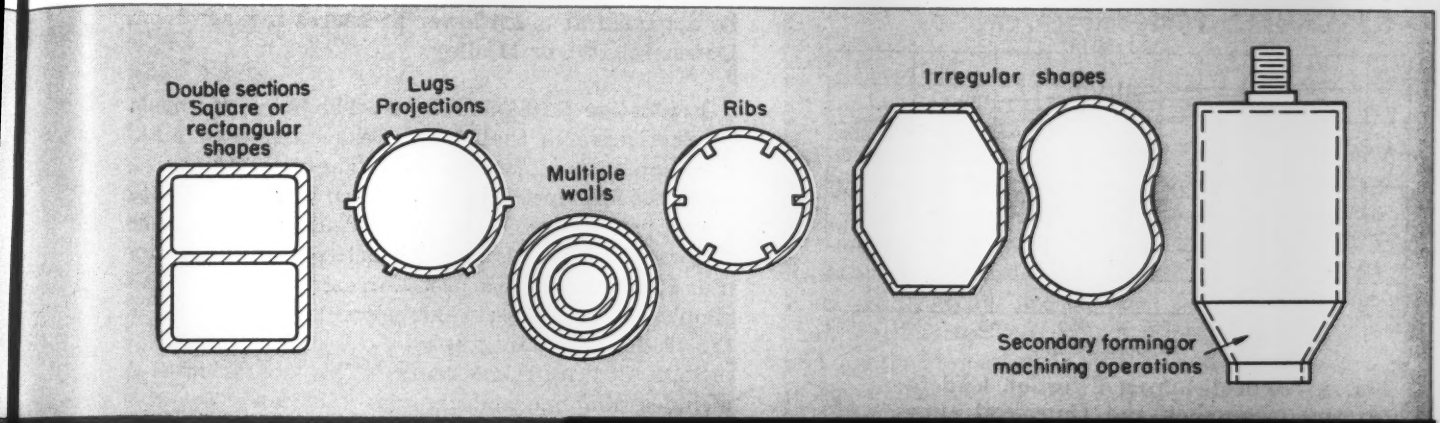
Impact extrusion should be considered for symmetrically shaped tubular parts when the following requirements are to be met:

1. The length-to-diameter ratio of the part ranges from 2-to-1 to as high as 15-to-1.
2. The bottom thickness differs from the wall thickness of the part.
3. Irregular profiles or ribs, flanges, bosses, etc., are required.
4. Smooth surfaces and good dimensional tolerances are desired.
5. Sharp corner radii are necessary.

Some possibilities of design with this method are illustrated in *Fig.* 1.

Magnesium and Impact Extrusion: Magnesium itself offers many advantages such as light weight (one-third lighter than aluminum), excellent resistance to many organic chemicals, oils, and alkaline solutions, good electrical conductivity, and availability. In looking back over the history of magnesium development, one needs only to note the price of magnesium ingot compared with other base metal prices to recognize that rapid technological advances have been made and that availability will play an important part in the use of magnesium in the future. As other metals are forced to lower grade ore sources, magnesium, which is available from inexhaustible sources like sea water, will take a more prominent place in design engineer's specifications.

Comparison of different metals shows that this high-speed, low-cost production operation taken together with lightweight, high-strength magnesium makes a desirable combination. One simple but outstanding example of this combination may be seen in *Fig.* 2. The small bracket shown in the picture was first designed to be blanked from sheet stock, flanges formed, corners welded, stress relieved, and sanded smooth. This same part made as an impact extrusion produces two parts in one



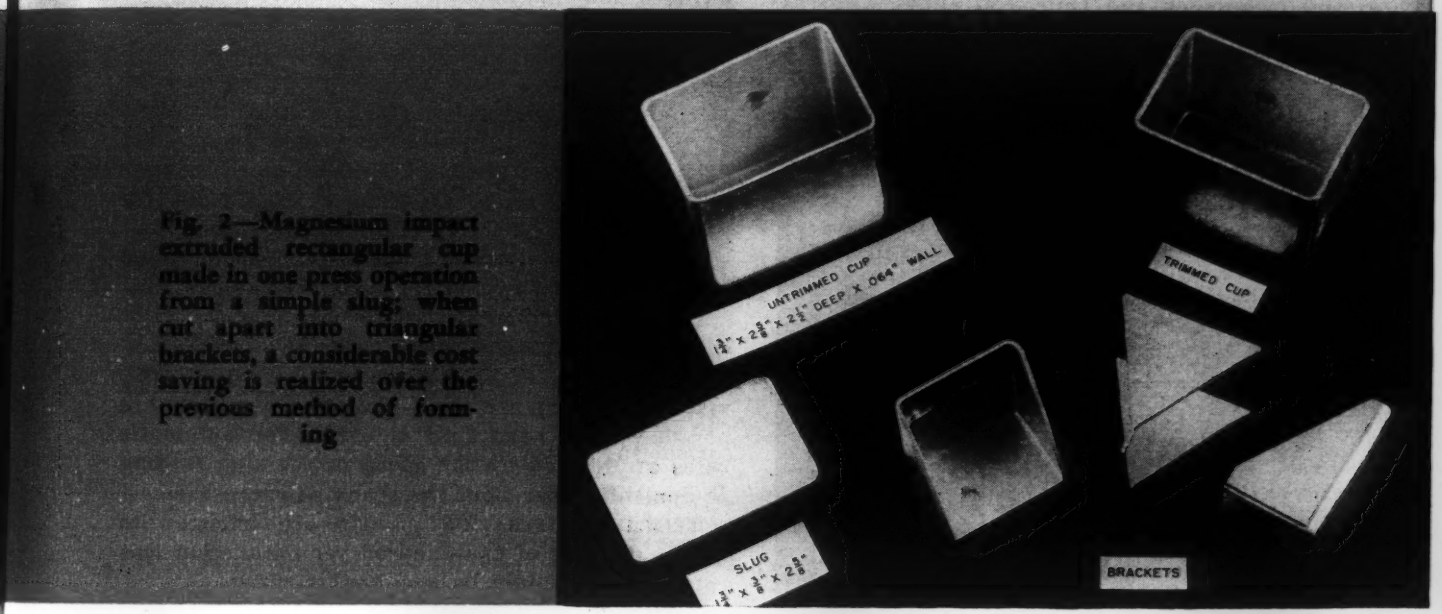


Fig. 2—Magnesium impact extruded rectangular cup made in one press operation from a simple slug; when cut apart into triangular brackets, a considerable cost saving is realized over the previous method of forming

simple press operation. Twenty-seven brackets weigh one pound when made from magnesium.

The family of curves in *Fig.* 3 show that this part (4.6 sq in. base area) made from Dowmetal ZK60A (TABLES 1 and 2) would require about 138 tons of pressure to impact extrude if the operating temperature is 600 F. The ultimate tensile strength of this material is about 50,000 psi (TABLE 3) while the tensile yield strength would be 37,000 psi. The pressure-temperature curves for various magnesium alloys, shown in *Fig.* 3, are to be taken only as approximations since many variables such as per cent reduction in area, type and amount of lubricant used, shape of slug, etc., affect the actual pressure required. This graph does, however, represent conservative data collected from production runs on hydraulic presses and from strain gage measurement made on impact extrusion punches mounted in both mechanical and hydraulic presses.

As another example of the pressure required for impact extrusion of ZK60A, the part shown in *Fig.* 4 is over 3 inches in OD and was extruded on a 200-ton hydraulic press at an operating temperature of 650 F. This same part, of course, could

Table 1—Chemical Compositions of Magnesium Extrusion Alloys

Dowmetal Alloy	Nominal Chemical Composition				
	Aluminum (per cent)	Zinc (per cent)	Manganese (per cent)	Zirconium (per cent)	Magnesium (per cent)
FS & FS1 ..	3.0	1.0	...	...	Remainder
J1	6.5	1.0	...	...	Remainder
M	...	...	1.2	...	Remainder
O1	8.5	0.5	...	...	Remainder
ZK60A	...	5.7	...	0.55	Remainder

Table 2—Physical Properties of Magnesium Extrusion Alloys

Dowmetal Alloy	Specific Gravity	Density (lb/cu in.)	Melting Point F	Coefficient of Thermal Expansion	Thermal Conductivity (C.G.S. units 212 to 570F)	Electrical Resistivity (Microhm Centimeters 68F)
FS, FSI .	1.77	0.064	1160	0.0000145	0.23	10.0
J1	1.80	0.065	1145	0.0000145	0.19	12.5
M	1.76	0.064	1200	0.0000145	0.30	5.0
O1	1.80	0.065	1130	0.0000145	0.18	14.5
ZK60A ..	1.83	0.066	1175	0.0000145	...	...

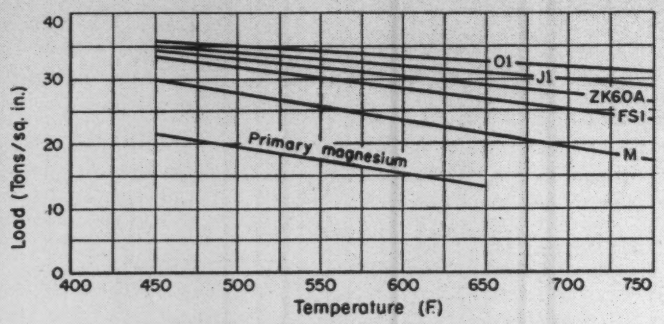
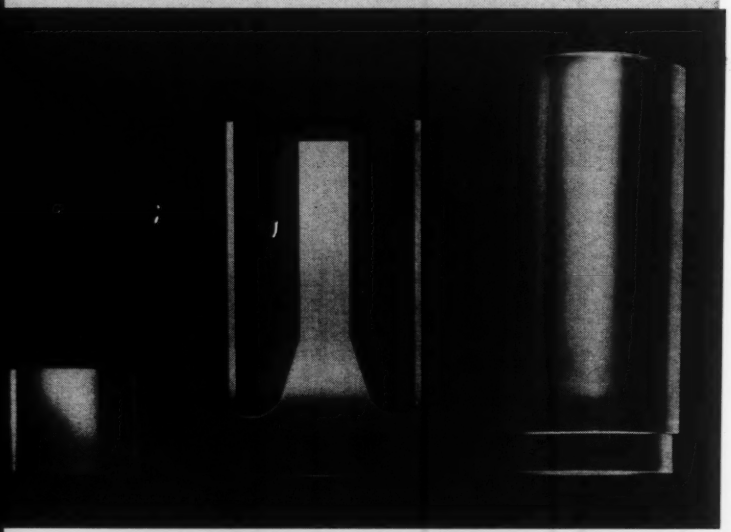


Fig. 3—Above—Impact extrusion load for primary magnesium and Dowmetal alloys versus temperature using graphite lubricant and 85 per cent reduction in area

Fig. 4—Below—Impact extruded part showing versatility of design. Part is made in one press operation from slug, left, of ZK60A alloy



be extruded at much lower pressures if made from Dowmetal FS1 or M alloy.

Production Rates and Costs: The press operation production rates that can be expected when making simple round, square or rectangular parts using hand feeding methods is between ten and twenty pieces per minute. Automatic feeding can increase this rate to as high as one-hundred parts per minute. Production rates used for estimating costs of simple round impact extrusions are outlined in the following paragraphs.

SLUG CUTTING OPERATION: This operation also includes tumbling and applying lubricant. Twenty-five to sixty pieces per minute for 1¼ inch diameter to ½ inch diameter parts are cut using an automatic saw with a three hp motor cutting one bar at a time. Extruded bar stock is generally used since the cost of this material is less than rolled plate and a better slug surface is obtained by sawing than when slugs are blanked from plate. In some cases the efficiency of sawing is higher than when slugs are blanked from plate. Sawing rates can be increased by sawing more bars at one time and by using higher powered saws.

IMPACT EXTRUSION OPERATION: Forty to one-hundred parts per minute are possible when automatic operations are used. Twenty per minute are possible when hand feed is used. The automatic rates are limited by the speed of the slug feeding equipment rather than the speed of extrusion.

TRIMMING OPERATION: Parts are trimmed to height at rates of one-hundred per minute but this rate is limited only by speed of trimmer.

CLEANING OPERATION: Chemical cleaning is used to remove lubricant from parts. This rate varies greatly depending on equipment used but with automatic equipment, this rate could be set up to

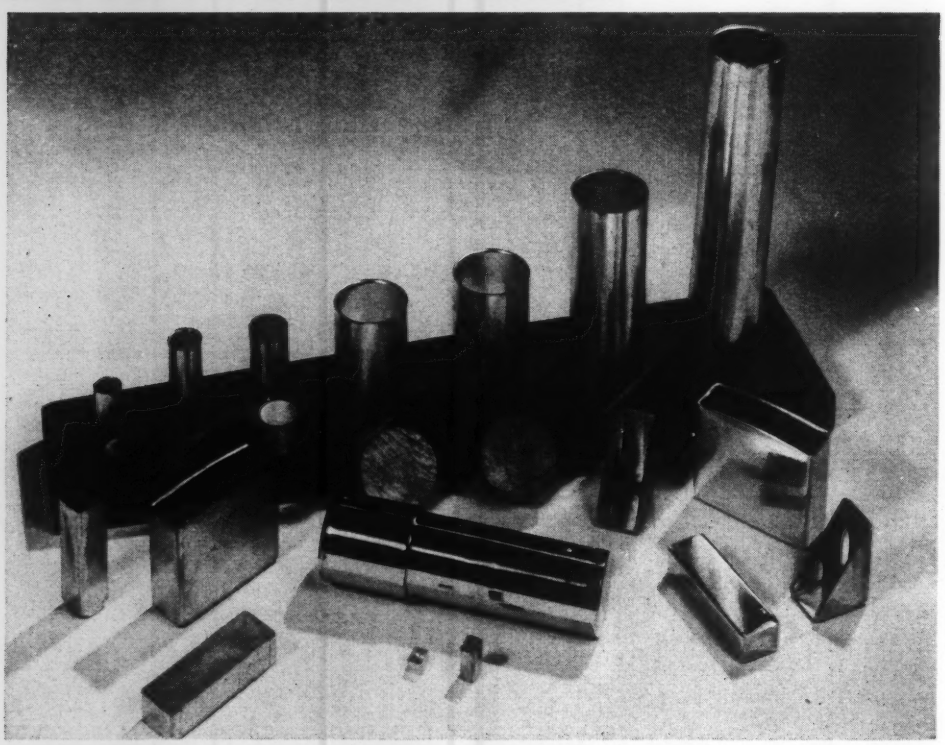


Fig. 5—Magnesium impact extrusions of relatively simple design showing slugs used in pressing

Fig. 6—Enlargement (5X) of the lower corner of the part in *Fig.* 4 shows flow pattern of metal

keep pace with the other operations.

By using these rates as a guide along with basic plant overhead costs, a unit cost can be estimated for various parts. For example, a simple round can —1-inch in OD by 4 inches high by 0.040-inch thick wall—set up for automatic operations taking 0.001-hour to fabricate would cost 0.4-cent per piece (fabrication cost only) in a shop having a labor and overhead cost of $4.00 per man hour.

The versatility of the impact extrusion process can be seen from some of the parts produced which are shown in *Fig.* 5. This is also indicated by the part in *Fig.* 4 which has a center stem, outside wall, and offset bottom flange incorporated and extruded from the simple billet at the left in the picture. It should be noted how many machine operations can be eliminated and how much metal can be saved by impact extruding as compared with machining such a part.

Design Considerations: The main point to be emphasized in designing parts to be impact extruded is to make parts symmetrical to prevent uneven metal flow and punch "wandering" with subsequent poor dimensional tolerances on wall thickness, concentricity, and straightness. Wall thick-

Table 3—Mechanical Properties of Magnesium Extrusion Alloys*

Dowmetal Alloy	Temper†	Tensile Strength (1000 psi) Typ	Tensile Strength (1000 psi) Min	Tensile Yield Strength (1000 psi) Typ	Tensile Yield Strength (1000 psi) Min	Elongation (% in 2 in.) Typ	Elongation (% in 2 in.) Min	Compression Yield Strength (1000 psi) Typ	Compression Yield Strength (1000 psi) Min	Shear (1000 psi)	Bearing Strength (1000 psi) Ult	Bearing Strength (1000 psi) Yield	Hardness Brinell	Hardness Rockwell E
FS & FS1	F	37	35	26	22	12	10	15	12	19	65	35	49	57
J1	F	44	40	30	24	14	10	19	14	19	74	43	60	72
M	F	34	30	20		9	3	12		18	56	28	44	45
O1	F	48	43	32	28	12	9		17	22	76	50	60	77
	T5	52	48	36	30	5	4	33	28	24	90	62	82	88
ZK60A	F	49	43	38	31	12	5	33	27	24	73	51	75	84
	T5	51	45	42	36	10	4	34	30	25	76	55	82	88

*Unless otherwise indicated, values are typical. †Condition F=as fabricated; T5=aged

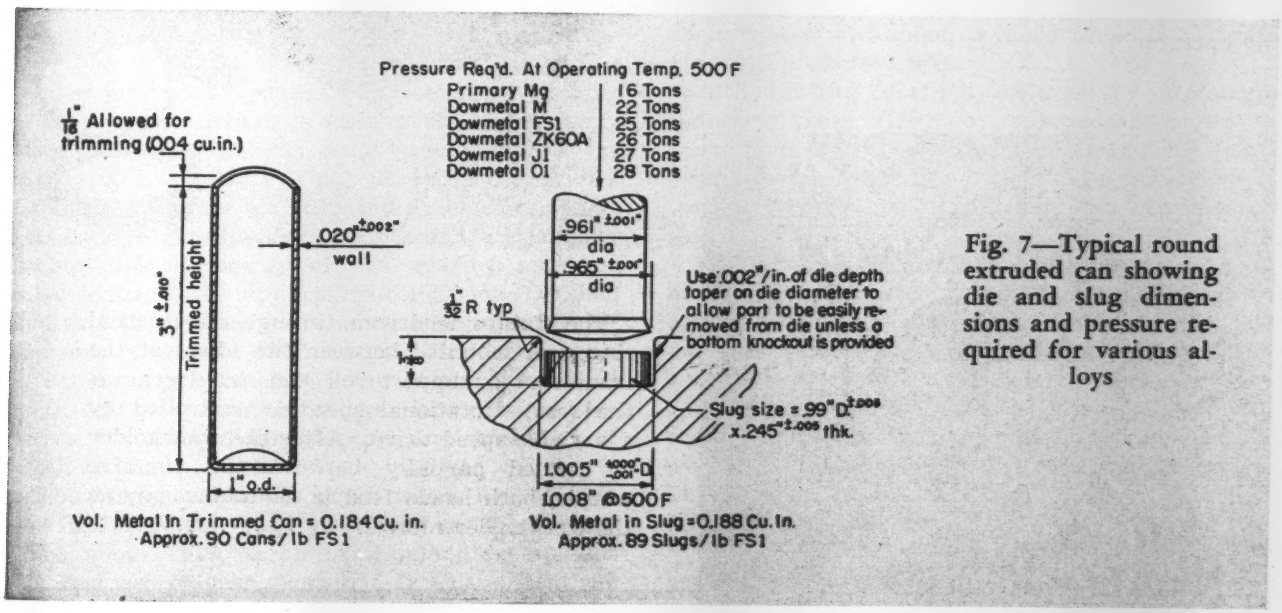


Fig. 7—Typical round extruded can showing die and slug dimensions and pressure required for various alloys

ness tolerances and concentricity depend upon several factors such as press alignment, shape of part, and length-to-diameter ratio of the part. In general, the following tolerances can be held on parts having a length to diameter ratio of 6-to-1:

0.020-in. thick wall	±0.002-in. variation
0.030-in. to 0.040-in. thick wall	±0.003-in. variation
0.045-in. to 0.055-in. thick wall	±0.004-in. variation
0.060-in. to 0.100-in. thick wall	±0.005-in. variation

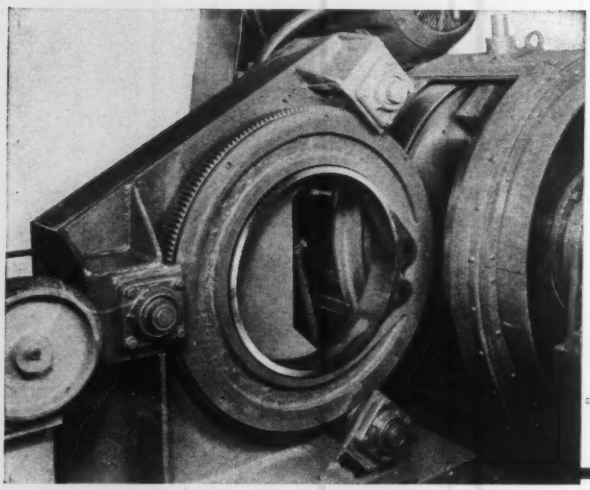
Bottom thickness tolerance is usually ±0.005-inch while the outside and inside diameters will vary somewhat with the size of the part with a tolerance of ±0.002-inch per inch of diameter being practical. At some points of an impact extruded part, a sharp corner radius may be permitted while at other points a generous radius may be necessary to avoid cracks caused by metal "flow-through". An example of this may be seen in *Fig.* 6. If a sharp bottom corner radius were used rather than the generous one shown, the part would have a crack where the flow lines converge in the center of the picture. In any case, when a complicated impact extruded part is desired, it is best for the design engineer to contact an impact extrusion vendor and submit preliminary sketches for comments on shape of part and allowable tolerances.

In *Fig.* 7 are shown some basic points to note when designing simple-shape parts. Tool factors, slug factors, and pressure required for making a 1-inch diameter by 3 inches deep by 0.020-inch wall part are indicated as a general guide. At the present time, the impact extrusion process as developed for magnesium shows promise that it will take a leading place among other metal working processes.

CONTEMPORARY DESIGN

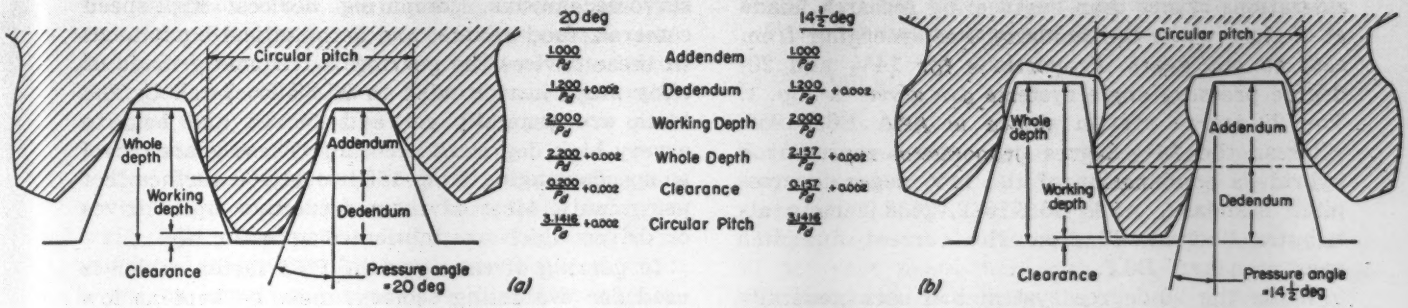
Brake Bands Ground In Rotating Workholder

TWO parallel sides of 16.2-inch OD brake bands are ground simultaneously by the No. 125-30″ double-spindle grinder of Gardner Machine Co. Brake drums are held in a special rotating workholder which is fed partially between the abrasive wheels by a hydraulically operated sliding work table. Spindles, 3.937-inch in diameter at the wheel collar end are driven through V-belts from two 40-horsepower, 1800-rpm motors mounted on hinged plates. Both heads are hydraulically operated, with the control valves being mounted at the front of the machine in convenient position for the operator.



The fixture is driven through an external ring gear mounted between two idlers at the front and a support roll and drive gear at the rear. Rotational speed is controlled by a variable-speed drive. After the workholder is carried partially between the abrasive wheels, both heads feed in simultaneously as the workholder rotates.

Fig. 1—Comparison of proportions for American Standard 20-degree involute fine-pitch system, *a*, and a 14½-degree system, *b*, as modified for fine-pitch service



Instrument Gears . . .

WHICH PRESSURE ANGLE?

Gear strength is favored by higher pressure angle, but in a comparison of 14½ and 20-degree systems,

WHAT ABOUT

Sliding **Thermal effect**
Bearing pressure **Backlash**
Undercut **Tooling**

By L. D. Martin
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Rochester, N. Y.

STANDARDS for gear tooth forms seem at first glance to have been thoroughly explored and resolved. Yet some aspects of this subject may not be generally appreciated.

For example, there is agreement among many gear designers that a tooth form standard for highly stressed gears is not necessarily desirable, particularly in the aircraft and automotive fields, for example. That is, for best use of materials and longest life, geometry of the gearing must be selected to fit the application conditions. Detailed analysis is necessary, including determination of the most favorable PVT factors. This latter term is an empirical factor relating to the scoring of teeth and is a function of the Hertz compressive stress, the tooth sliding velocity, and the length of tooth action.

The Maag system for gears which has been in use in Europe for many years, and in this country since about 1918, is an outstanding example of the best use of gear geometry. In this system the properties of the involute curve are exploited to their fullest advantage, without favor to a single standard pressure angle.

Although this ideal may be achieved in a single industry, there are many economical factors in favor of standard tooth form systems. This is especially true in the fine-pitch field which covers a considerably wider range than the coarse-pitch field.

Fine-pitch gears have been established as gears of 20 diametral pitch and finer. The coverage in existing fine-pitch standards is from 20 to 200 diametral pitch, a span of 180 pitches. In the coarse-pitch field there are only approximately 20 pitches to consider. Because of tooling problems, custom designing—all other factors being equal—would be impracticable in the fine-pitch range. Therefore standard tooth form systems are highly desirable in this field.

The current thinking among standards making bodies is that tooth form systems, now under de-

velopment, should center around 20 and 25-degree pressure angle. The 14½-degree system is admittedly archaic and will not meet the needs of this age. It was an arbitrary choice, based on practical considerations rather than engineering research, made at a time when the industry was emerging from cast to cut gears. Proportions for 14½ and 20-degree pressure angle systems are given in *Fig.* 1. The 20-degree system shown is ASA B6.7-1950, whereas the 14½-degree proportions represent a hybrid—a combination of the 14½ degree coarse-pitch standard, ASA B6.1-1932, plus certain attributes "borrowed" from the current fine-pitch gear standard, B6.7.

While the 20-degree system has been generally adopted for instrument gears, both in this country and abroad, there are still an appreciable number of instrument manufacturers who, for one reason or another, have not adopted the 20-degree system. Some manufacturers are retaining the archaic 14½-degree system, because of interchangeability requirements of equipment in the field. They cannot entirely divorce themselves from it for economical reasons. It is quite probable that a study would disclose that the advantages to be gained from adopting the newer tooth form system would probably outweigh the sacrifices—when all advantages are recognized.

It is the purpose of this article, generally, to discuss some of the more subtle points to be considered by designers in arriving at a choice of pressure angle and, specifically, to compare the significance of those points in relation to the two pressure angles, 14½ and 20 degrees.

Types of Service: Fine-pitch gears can be roughly divided into two groups: those that are used to transmit power at relatively high speeds and those used to transmit motion at relatively low speed.

Among the high-speed fine-pitch applications are servomechanisms, computing devices, high-speed cameras, food mixers, and aeronautical equipment. In these devices the gearing is frequently made of alloy steel, heat treated to 35-38 Rockwell C. The teeth are generally cut and shaved and held to a very high degree of accuracy. These gears travel at speeds ranging from 1500 to 11,000 surface feet per minute. Most of them are either open drives or drives which are lubricated once for life.

In gearing of this type the PVT factor, which is used for evaluating scoring, must be kept as low as possible. John O. Almen and his associates of the Research Laboratories of General Motors have pointed out that the resistance to pitting and scoring of gears is increased by increasing the pressure angles. This fact is in accordance with the Hertz theory on the stresses produced by the pressure of one cylinder upon another. AGMA Report 101.02 by Straub and Wholers, October 1951, points out that the maximum compressive stress varies, roughly, as the reciprocal of the smaller radius of curvature of the teeth, and that radius is theoretically zero at the base circle. Therefore, to avoid high compressive stresses and high scoring factors, it is necessary to avoid tooth action near the base circles. This report points out that satisfactory contact ratio is very important. Too high a contact ratio may lead to high sliding and therefore premature wear and failure.

In a test involving 2000 gear sets, failures due to scoring were completely eliminated by increasing the pressure angle from 20 to 25 degrees. All this points to the incontrovertible fact that gears of

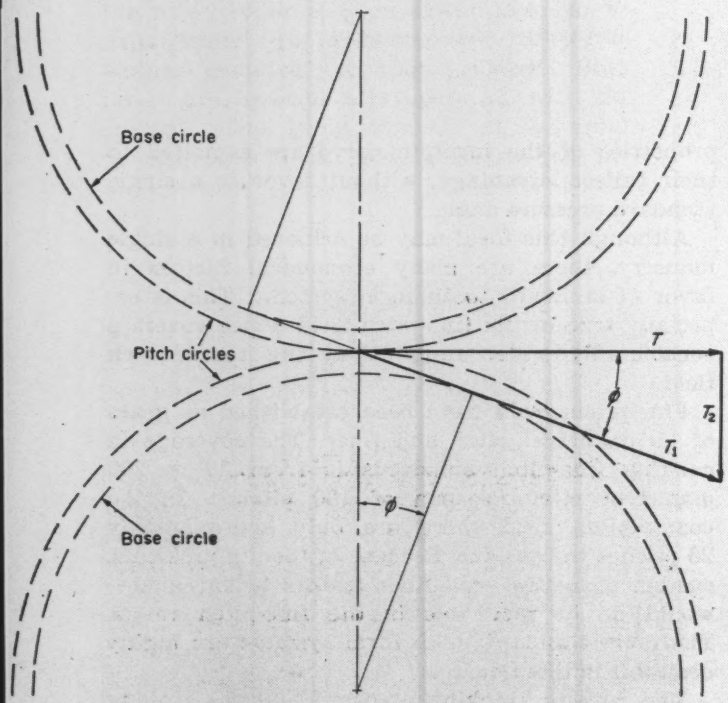


Fig. 2 — Left — Relationship of tangential force T, total tooth force or bearing pressure T_1, and force T_2 which tends to separate the axes

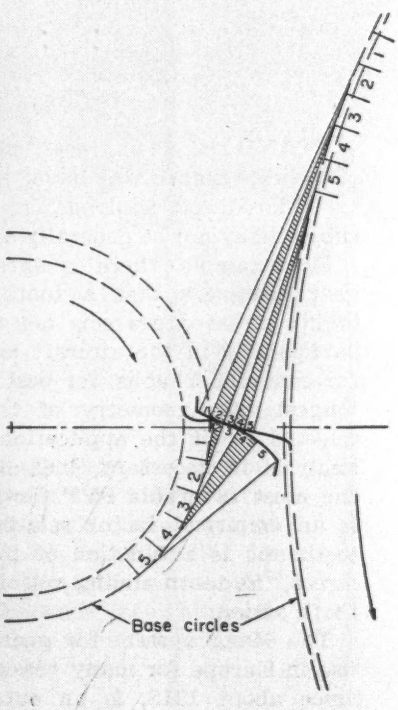


Fig. 3—Right—Sliding for a 10-tooth enlarged pinion meshing a 50-tooth reduced gear, at standard center distance, made in accordance with American Standard 20-degree fine-pitch

14½-degree pressure angle have less surface durability and lower beam strength, especially where small pinions are used.

The vast majority of power drives falling within the fine-pitch range are made in accordance with American Standards. Some gears are made with stubbed teeth in order to increase the beam strength and yield a more favorable contact ratio. A great many of these power-drive gears are made to operate with very little backlash.

The second general group of fine-pitch gears are used in motion drives where loads are generally light; lost motion due to backlash is critical, and speed very slow. In these gears beam strength is not as important as surface durability and retained accuracy. Since most of these gears operate with very little or no backlash, a wide choice of materials and surface finish is required to prevent wear which would otherwise be detrimental to the operation of the device. It is also with gears of this type that the 20-degree tooth form system shows its superiority over the 14½-degree system.

Bearing Pressure: Some of the objections to gears of 20-degree pressure angle stem from wrong conceptions or half truths gotten from out-of-date handbooks. One of these notions is the thought that gears of higher pressure angles introduce much greater bearing pressures and operate with more friction. These tendencies are present but are they significant?

The bearing pressure is often confused with the force which tends to separate the axes of the gears. As *Fig.* 2 shows, there are three force vectors involved: T, the tangential force passing through the pitch point; T_1, the tooth pressure acting along the line of action; and T_2 (vectorial difference of T and T_1), the force tending to separate the axes.

Force tending to separate the axes is

$$T_2 = T \tan \phi \qquad (1)$$

For the same transmitted torque, therefore, T_2 is proportional to tan ϕ, or to 0.2586 for 14½ degrees and 0.36397 for 20 degrees. Thus, the force tending to separate the axes with 20 degrees is 40 per cent more than with 14½ degrees. It is significant in magnitude, but is no indicator of bearing pressure.

The total bearing pressure must be equal to T_1, the tooth pressure. In terms of transmitted torque, the total bearing pressure is

$$T_1 = \frac{T}{\cos \phi} \qquad (2)$$

It is obvious, therefore, that the relative bearing pressures of 14½ and 20-degree pressure angle gears are inversely proportional to the cosines of the pressure angles. Cos 14½ degrees = 0.96815, cos 20 degrees = 0.93969, and the difference is 0.02846 or less than 3 per cent. This difference, even for highly sensitive instruments, is negligible. A more significant effect of change in pressure angle upon bearing pressure is a change in its direction.

Specific Sliding: Some of the references on gearing are not too clear on the meaning of profile or specific sliding. Examples are often given with the purpose of showing that gears of higher pressure angles have greater specific sliding than gears of lower pressure angles where high ratios are used. Profile sensitivity of high pressure angle gears is mentioned, causing great misgiving in the minds of some. It can be shown that there is, actually, more sliding in 14½-degree gears than in those of 20 degrees when the same ratios and conditions of undercut exist.

Specific sliding may be explained in the following way. Any infinitely small portion of the involute profile may be considered an arc of a circle with a radius equal to the length of the generating line to that point. Specific sliding can be defined as the quotient of the difference of the arc length of the pinion and gear acting on each other through an angular increment of rotation—depending on whether the sliding is considered on the gear or pinion profile.

When the lengths of the radii of the two infinitely small arcs in contact with each other are directly proportional to the numbers of teeth in the gears, pure rolling action will result. This condition occurs, in involute gears, at the point where the line of action crosses the line of centers, or the pitch point. At all other points sliding must occur. The most favorable conditions of sliding, wearwise, are obtained by staying as far away from the base circle as possible.

Fig. 3 shows a 10-tooth enlarged pinion meshing

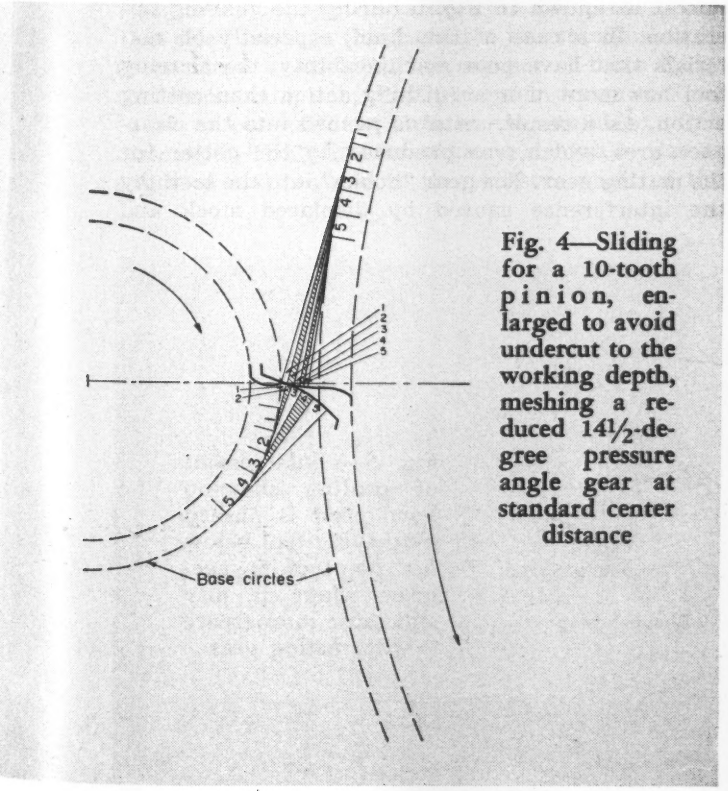
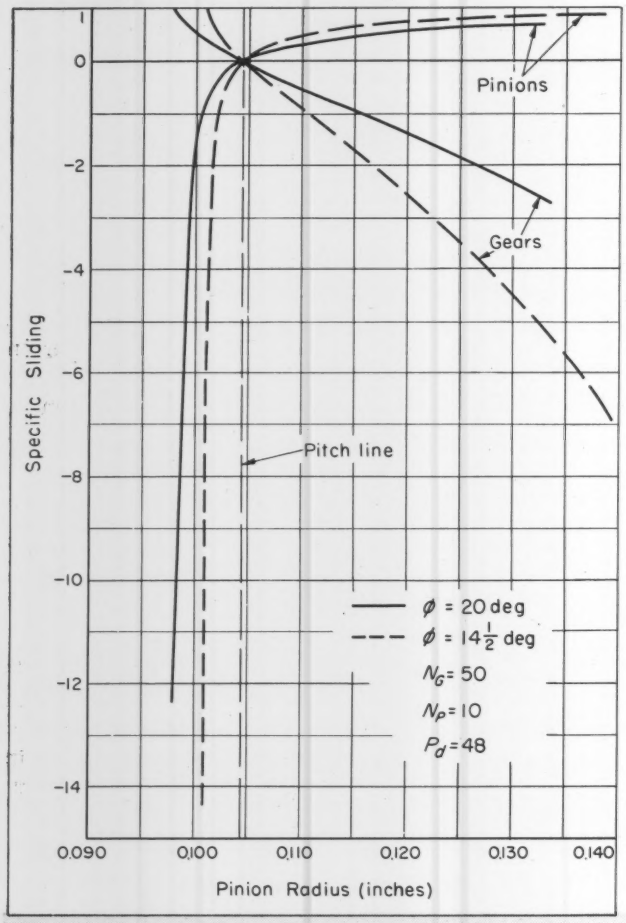


Fig. 4—Sliding for a 10-tooth pinion, enlarged to avoid undercut to the working depth, meshing a reduced 14½-degree pressure angle gear at standard center distance

a 50-tooth reduced gear, at standard center distance, made in accordance with American Standard 20-degree involute fine-pitch system. These gears are commonly known as long and short-addendum gears. *Fig.* 4 shows the same 10 and 50-tooth combination cut with a 14½-degree cutter. The pinion is enlarged to avoid undercut down to the working depth as is the American Standard pinion. The mating 50-tooth gear is reduced an amount equal to the enlargement of the pinion. The operating pressure angle of this combination is 14½ degrees, the same as the pressure angle of the generating tool. An observation of the relative profile lengths of the same angular increments of rotation shows that there is more specific sliding on the 14½-degree than the 20-degree combination. This is clearly shown on *Fig.* 5 where quantitative values for the sliding for both combinations are given.

Fig. 5 — Comparison of specific sliding for gear combinations shown in *Figs.* 3 and 4



Undercutting: Undercut pinions have the following disadvantages: (1) They are considerably weaker than those without undercut; (2) they have a much shorter arc of contact because part of their active profile is removed, and (3) the undercut is often a source of interference with the tops of the teeth of the mating gear.

Undercut is a result of the generating action of the gear cutting process. The tip of the generating tool sweeps out a trochoidal curve which is required to provide the necessary clearance for the mating member. If this trochoidal curve is modified in any manner, trouble is apt to result. This is especially true when gears operate metal to metal without backlash and are at their nominal size on outside diameter.

The trochoidal curve might be altered in several ways. It can be changed to provide more clearance for the tip of the mating gear by use of a gear shaper cutter that has been sharpened back and has thin teeth. It can be made shallower to produce interference with the tips of the mating gear by the development of a large fillet radius at the top of the generating tool. This often happens as a result of wear, on the leading-in side of the hob or gear shaper cutter, especially in the machining of materials such as 18-8 stainless steel. Modification of the trochoidal curve can also occur by rolling stock into it as shown in *Fig.* 6 during the shaving operation. In a case of this kind, especially on materials that have poor machineability, the shaving tool has more of a burnishing action than cutting action. As a result, metal is pushed into the clearance area which was produced by the cutter for the mating gear. The gear "hooks" into the teeth by the interference caused by displaced stock and

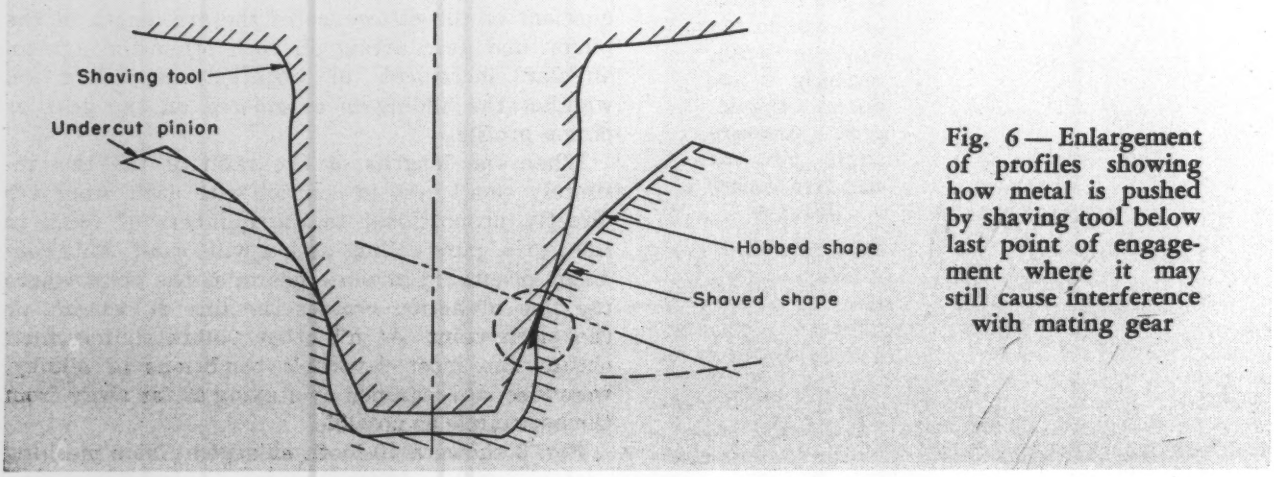


Fig. 6 — Enlargement of profiles showing how metal is pushed by shaving tool below last point of engagement where it may still cause interference with mating gear

conjugate action is destroyed, *Fig.* 7. If the teeth were not undercut, the shaving tool would cut away the metal instead of pushing it into an unsupported area.

The current standard whole depth for fine-pitch gears is $(2.200/P_d) + 0.002$, which provides a proportionately greater depth as the pitch becomes finer. For this reason undercut varies with the pitch. At 48 diametral pitch, for instance, undercut starts at approximately 41 teeth in gears of 14½-degree pressure angle. Pinions made in accordance with the American Standard have no objectionable undercut.

Backlash: The users of 14½-degree pressure angle gears cite, as an advantage, the fact that in backlash they are less susceptible to center distance error than gears of higher pressure angle.

It is true that the change in backlash is equal to two times the tangent of the operating pressure angle times the change in center distance. Consequently, for 14½-degree gears, a change of 0.001-inch in center distance results in a change of approximately 0.0005-inch in backlash. The equivalent backlash change for gears of 20-degree operating pressure angle is about 0.0007 inch. On the face of it, there is a difference of approximately 40 per cent in backlash sensitivity in favor of 14½-degree gears. However, it is the *operating* pressure angle that controls the relative change of backlash to center distance and not the pressure angle of the generating tools. Involute gears have no pressure angle until they are mated with other involute gears at a fixed center distance.

Fig. 8 shows the difference between standard and operating pressure angle. In *Fig.* 8*a* are shown the base radius of a pinion, R_{bP}, and the base radius of the gear, R_{bG}. The common tangent to these radii intersects the line of centers at the pitch point. The pitch radii in this case are the standard radii as obtained by dividing the number of teeth N, by the diametral pitch, P. The center distance C_1 is equal to one-half the sum of the standard pitch diameters. The pressure angle, ϕ_s, in this case is standard and is equal to the pressure angle of the generating tool. It can be expressed as

$$\cos \phi_s = \frac{R_{bP} + R_{bG}}{C_1} \quad \ldots\ldots (3)$$

where

$$R_{bG} = \frac{N_G \cos \phi_s}{2 P_d} \quad \ldots\ldots (4)$$

$$R_{bP} = \frac{N_P \cos \phi_s}{2 P_d} \quad \ldots\ldots (5)$$

In *Fig.* 8*b* are the same base radii R_{bP} and R_{bG} but the center distance has been increased. The operating pitch diameters are larger than the standard pitch diameters. The new center distance C_2 is proportionately larger as well as the operating pressure angle ϕ_o. The line of action or common tangent to the two base radii intersects the line of centers at a different point and forms a much greater angle with a line normal to the line of centers than it did in *Fig.* 8*a*. The formula for operating pressure angle is

$$\cos \phi_o = \frac{R_{bP} + R_{bG}}{C_2} \quad \ldots\ldots (6)$$

This difference between the standard and the operating pressure angles is frequently overlooked by those who specify 14½-degree pressure angle gears. Examination of gear applications originating with some companies who are wedded to the 14½-degree system revealed three applications in which a 14½-degree pressure angle was specified but in which the pinions were enlarged (cut oversize) without a corresponding reduction in the mating gear. The *operating* pressure angle in these three cases were 16 deg 13 min, 17 deg 1 min, and 21 deg 4 min. Had these gears been made in accordance with the American Standard fine-pitch system, they would all have had a 20-degree pressure angle.

Thermal Effects: In these days of precision gear-

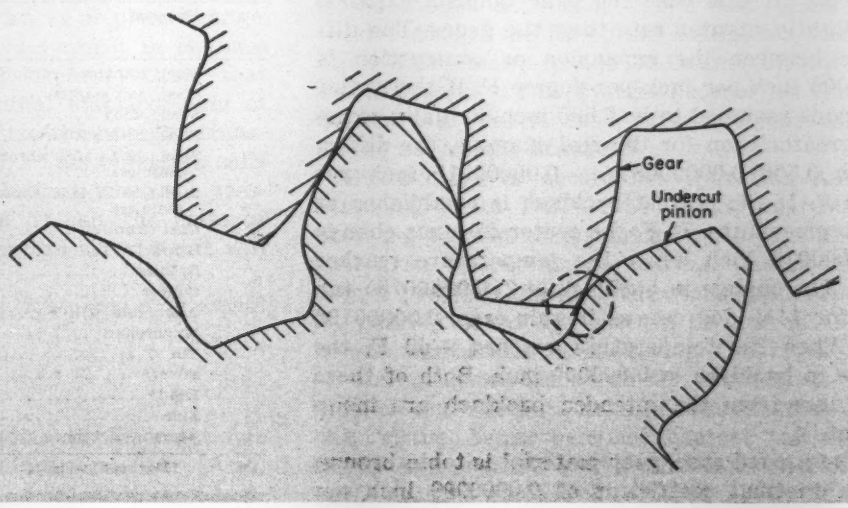


Fig. 7 — Detail of pinion and gear engagement showing interference resulting from metal displaced into undercut by shaving tool

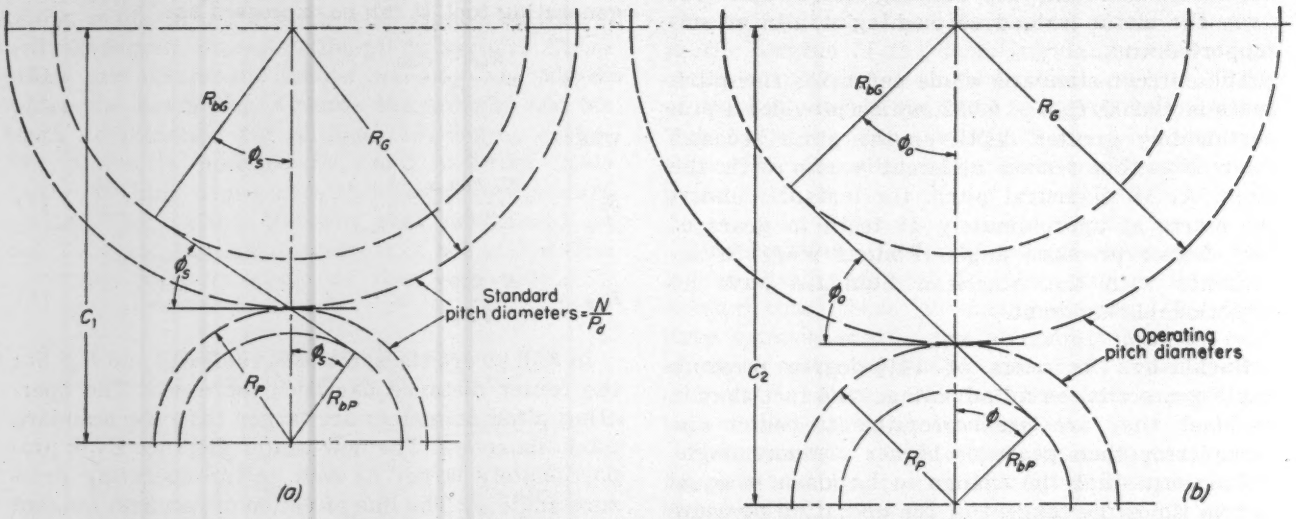


Fig. 8—Comparative geometry for pair meshing at standard and nonstandard center distances

ing it is no special hardship to hold gear size to a few tenths of a thousandth of an inch. Shaving and lapping equipment especially suited to fine-pitch gears makes this possible. Also better means of obtaining and measuring size are currently available than a decade ago. Holding close backlash requirements at room temperature is no trick regardless of pressure angle, whether 14½ or 20 degrees. It is being done every day.

The argument can be advanced that backlash must be maintained over a wide temperature range since many instruments operate at 120 F to −60 F. Now, if the gears are made of a material that has a different thermal coefficient than that of the plates or housing, backlash will be affected. This is true if an unwise choice of materials is made. Two typical cases will give some idea of the magnitude of the thermal effect.

In one case, gear material is 18-8 stainless steel, and the housing is bronze. From TABLE 1, the thermal coefficient for 18-8 stainless steel is 0.0000096 inch per inch per degree F. That of bronze is 0.0000099. In this case the gear housing expands at a slightly greater rate than the gears. The difference between the expansion or contraction is 0.0000003 inch per inch per degree F. If the center distance is assumed to be 0.500 inch, actually somewhat greater than for the real example, the difference is 0.500(0.0000003) = 0.00000015 inch per degree F. If the correct backlash is established at room temperature, 70 F, the center distance change is 0.0000075 inch when the temperature reaches 120 F. The change in backlash is 2(0.0000075) tan ϕ, or for 14½ degrees, as in this case, 0.00000194 inch. When the temperature reaches −60 F, the change in backlash is 0.000009 inch. Both of these departures from the intended backlash are insignificant.

In the second case, gear material is tobin bronze, with a thermal coefficient of 0.0000099 inch per inch per degree F and the housing is casting aluminum, 17S—T with a thermal coefficient of 0.0000123. The difference is 0.0000024 inch per inch per degree F. The center distance is 0.6875 inch. The difference in backlash at 120 F is therefore 0.00004267 inch. The difference at −60 F is 0.00011 inch. Both of these amounts are of no significance.

Obviously, when a wise choice of materials is made for motion-drive instrument-gear trains, pressure angle—whether 14½ or 20 degrees—has no effect on backlash.

Manufacturing Influences: Any engineering problem is a compromise between all the desirable features that can be obtained and the few undesirable conditions that cannot be avoided for practical and economical reasons. Sometimes the limitations of the tooling for the particular art set the boundaries of the attainable and unattainable.

Table 1—Coefficients of Expansion

Material	Coefficient (in./in./deg F)	Ratio (to carbon steel)
Steel, hardened carbon	.000 0066	1.
Steel, soft carbon	.000 0061	0.92
Steel, alloy	.000 0073	1.1
Steel, 18-8 stainless	.000 0096	1.45
Steel, 12 to 15% chromium stainless	.000 0057	0.86
Steel, 16 to 18% chromium stainless	.000 0058	0.88
Cast iron	.000 0056	0.85
Brass	.000 0096	1.45
Bronze	.000 0099	1.50
Copper	.000 0089	1.35
Aluminum 17S-T	.000 0123	1.86
Magnesium	.000 0144	2.19
Tin	.000 0127	1.93
Silver*	.000 0108	1.63
Lead*	.000 0157	2.38
Zinc	.000 018	2.73
Aluminum bronze	.000 0094	1.42

*For comparison.

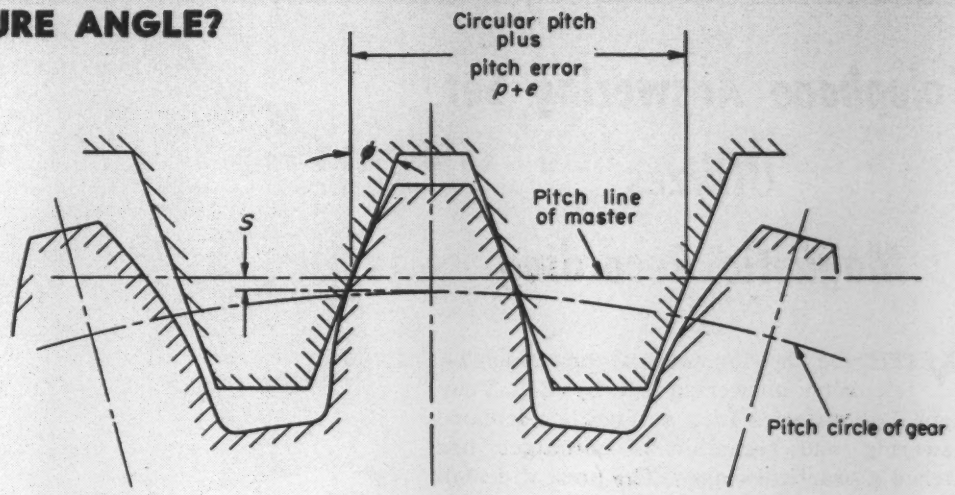


Fig. 9 — Effect of pitch error e on radial displacement S

This is pretty much the case for precision motion-drive instrument gearing. In such gearing, angular transmission is of first order of importance; backlash is of secondary importance and can usually be avoided in a number of ways.

The accuracy limitations of the tooling such as hobbing machines, gear shaper cutters, shaving tools, etc., generally establish the limits of attainable accuracy of gears. Blank construction and mounting are also very important, but these are things that can reach a high order of perfection if the correct techniques are used. Meeting stringent tolerances with gear cutting equipment which is not built to yield the desired accuracy poses a big question. Yet, this is the problem facing gear engineers.

It has been stated that play, or backlash, in gear teeth is a function of the radial displacement and the tangent of the operating pressure angle. Another way of putting this is to state that any error which affects the play between the teeth, such as tooth thickness variation, pitch error, profile error, or lead error, causes a change in radial displacement which is related to the pressure angle. The lower the pressure angle, the greater the radial displacement for a tooth thickness or pitch change. Changes in radial displacements result in changes in angular transmission. It follows, then, that the smaller the effect on radial displacements of the mentioned errors, the better the angular transmission that will be obtained. This objective calls for higher pressure angles. In fact, when the pressure angle is 26 deg 33 min 54 sec, the ratio of radial displacements to the errors affecting it will be one to one.

Fig 9 shows the effect of pitch error e on radial displacement S. That is,

$$S = 2e \cot \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

In this illustration, the radial displacement has been shown by a gear meshing a master. Also, for the purpose of simplicity, pitch error has been shown as the only component affecting radial displacements. Actually there are several other errors which also cause radial displacements.

The undulating errors of hobbing machines are very complex to analyze, but their pattern is traceable on the work produced. The same thing is true of gears produced on a gear shaper. The errors of the cutters and/or index worm wheels are traceable on the gears. It is well known that gears of high pressure angle reflect less of the undulating error of the hobbing machine and index error of gear shaper wheels and cutters. It is also common knowledge among cutter manufacturers that greater accuracy can be built into a high pressure-angle cutter than in one of low pressure angle. A choice must be made between the primary objectives of angular transmission or the secondary objective of backlash control.

Summary: During the development of the fine-pitch system, at least five tooth form systems were studied. The advantages and shortcomings of each system were considered. The diverse problems of the tooling and available gear cutting and finishing equipment for the fine-pitch field were given careful attention. After two years of intensive study, the fine-pitch committee settled on the system known as the 20-Degree Involute Fine-Pitch System. This system became an American Standard in March, 1950, after a 7-year trial period as an AGMA Standard.

Gears made in accordance with this American Standard (ASA B6.7—1950) today represent the best engineering compromise of the pros and cons that arise in instrument gearing. Gears of 14½-degree pressure angle, on the other hand, are steadily passing out of the picture because of their inherent limitations in satisfying the requirements of strength, surface durability, smoothness of operation, and accurate angular transmission. Their only virtue, better backlash control, can be practically matched by a wise choice of materials or compensating devices.

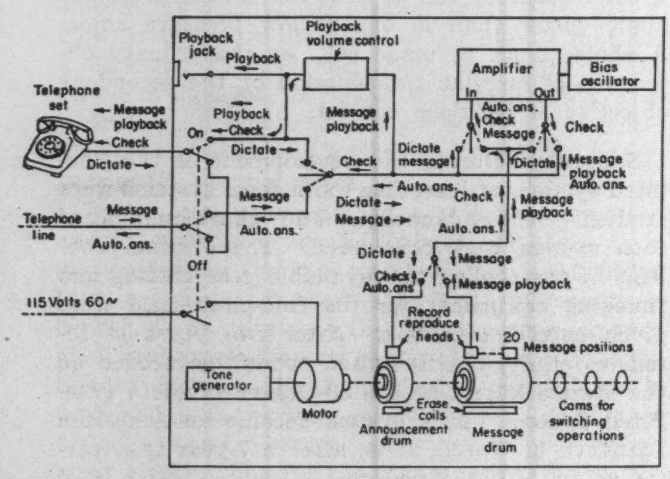
Telephone Answering Set Utilizes Magnetic Recording

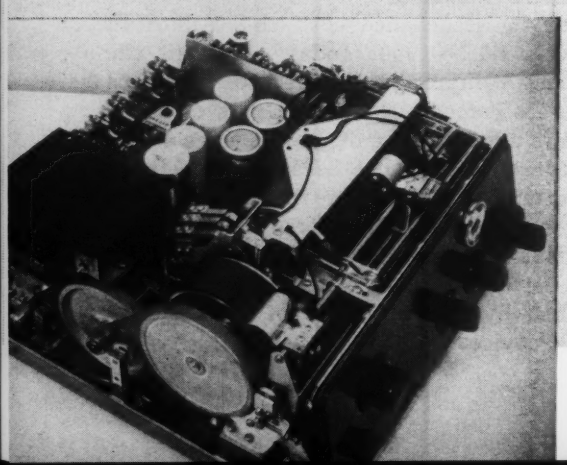
Photos, courtesy
Bell Laboratories Record

WITH the development of the model 1A telephone answering set by Bell Telephone Laboratories Inc., automatic telephone answering and reception of messages has reached a practical stage. The present design is about the size of a portable typewriter and is used in conjunction with the usual telephone. With the function knob (left) set to *automatic answer*, the set is automatically started by an incoming call, gives the calling party a previously recorded message, records the incoming message, disconnects the line, and stops. Total incoming message recording time is about 10 minutes, or 20 messages of 30 seconds each.

In normal operation, the function knob is turned to *announcement dictate* and the *start* button (left below) is pressed. When a red signal light appears under the *dictate* position, the outgoing message is dictated and the *stop* button (right below) is pressed, which may be any time between 15 and 30 seconds later. The message may be listened to by turning the function knob to *announcement check* and again pressing the *start* button.

The function knob is then set to *automatic answer* and the message scanning knob (right) to zero. As incoming messages are recorded, the indicator dial around the message scanning knob shows how much recording space has been used. Turning the function knob to *playback*, the message scanning knob to zero and pressing the *start* button permits recorded incoming messages to be heard through the telephone or separate receiver.





Two magnetic drums, incorporating resilient "magnetic rubber" surfaces are the heart of the set. The outgoing message is recorded on the smaller drum, while the other is utilized for incoming messages. Simplified speech paths are shown as well as manual switch operation. Erasure of the outgoing message is automatic when a new message is recorded, while incoming messages are erased on the first call of a new sequence. Thus, recorded calls may be played back any number of times. Timing of signal tones and of maximum incoming message length is accomplished by gear-driven cams, which can be instantly reset since they are driven through a solenoid-operated clutch and spring returned. An automatic volume control for incoming messages is used, and playback volume control is adjusted by a separate knob (center right on first photo).

Seven relays and 43 mechanically operated switches are crammed into the unit. About half of the latter are on a pair of slide switches operated by the function knob, and most of the rest are actuated by the timing cams or by motion of the recording head carriages. Long-life recording heads trace helical paths on the drums as the heads are moved laterally by lead screws.

Hydraulic Slide-Valve Forces

. . . their effect on response of servo systems

By James M. Nightingale
Servo Engineer
Manchester, England

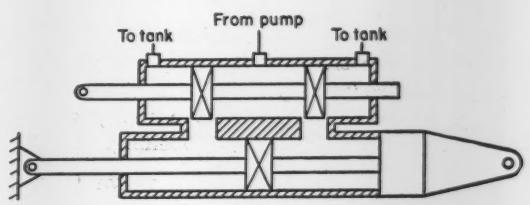


Fig. 1 — Typical coupling of hydraulic cylinder and valve forming a closed-loop device or servomechanism

WITH the increased use of sensitive hydraulic control systems in recent years, the design of hydraulic slide valves has come under critical review, and subsequently a considerable amount of development work has been undertaken. Not the least of this endeavor has been directed toward the reduction of axial forces opposing signalled motion of the valve spool, primarily with a view to increasing the power amplification ratio of the slide valve. However, by their very nature these valve forces can give rise to unwanted oscillations, so that there may be other good reasons for trying to eliminate them.

Slide-valve amplifiers and cylinder type hydraulic motors are frequently used together in hydraulic control systems, particularly in high-performance aircraft systems. Numerous arrangements are known for mounting the valve and cylinder, but coupled as in *Fig.* 1 they constitute a closed-loop device or servomechanism. Problems of response and stability, encountered to some degree in all servo systems, are rather severe in this type of mechanism since there are rather large time lags due to the effect of output load on the flow from the valve, and also due to elasticity in the fluid and the cylinder. The response of the unit can be defined by a linear transfer function for small valve openings. Cylinder velocity is limited by the maximum possible valve opening, so that the response to a large input displacement takes the form shown in *Fig.* 2. Over most of the travel the system is in the saturated condition with the valve fully open, but there are two bands, when the valve is opening or closing, within which the response is defined by the linear transfer function. In these zones of linearity, instability and oscillation are likely to occur, but by readjusting the factors which influence the damping in the unit, a suitable response can be obtained.

When the unit is mounted in an aircraft, or on a test rig designed and tuned to simulate aircraft operating conditions, other factors come into effect, many of which are destabilizing and tend to cause oscillations. Examples of such factors are backlash and resilience in the input and output circuits, and in analyzing results it is difficult if not impossible to separate those oscillations which are inherent in the closed loop unit from those promoted outside the loop in the various linkages. Backlash may be substantially eliminated by fitting suitable bearings and by preloading, while flexibility in the output circuit is usually stabilized by inherent damping at the output. On the other hand, flexibility in the input circuit together with axial forces acting on the valve may induce cross-coupling between the output and the input circuits, giving rise to sustained oscillations. The extent and persistence of these oscillations depends on the nature of the valve forces and in this article their effect on the system response is investigated.

Kinds of Forces: The axial forces acting along the slide-valve spool are indeterminate and very random in their form since so many uncontrollable factors influence them. Some attempt has been made to separate them[1,2,3] and they may be classified broadly in three groups:

1. Friction forces due to adhesion between the

[1] References are tabulated at end of article.

valve lands and the sleeve. These are particularly indeterminate, varying, among other things, with time since silting-up and wedging occur when the valve is stationary for any length of time. The friction force per land has been quoted as high as $0.07ps$, where p is the pressure drop across the land, and s the projected area of land. When a critical velocity is reached, film lubrication occurs between the valve lands and the sleeve and the friction force falls to very small values.

2. Dynamic flow forces or so-called Bernoulli forces. Lee and Blackburn[2] show that flow forces comprise a steady-state force, together with a force proportional to valve opening and tending to close the valve, and also a force proportional to valve velocity whose sense depends on the geometry of the valve lands and ports.
3. Fluid damping forces. These forces are generated by restrictions in the flow paths, or may be introduced purposely in the form of a damping orifice. They vary roughly with the square of velocity of valve opening.

A typical variation of the net valve force with valve velocity is shown, *Fig.* 3, together with the separate components which comprise it. Exact prediction of the magnitude of the force is out of the question, but it is possible to speculate in the light of previous experience. In particular F_m and V_c can be fixed with reasonable accuracy. It is of interest to investigate the effect of a typical valve force on the overall system performance.

Nomenclature

D = Differential operator
E = Shift operator
e = Valve opening
e' = Valve velocity
$F(e')$ = Axial valve force
k = Stiffness of input circuit
T = Servo time constant
t = Time
x = Input displacement
$Y(D)$ = Loop transfer function
y = Output displacement
δ = Finite time interval
μ = Servo gain constant

Method of Analysis: Relative stability of the system can be observed from its transient response to a sudden valve displacement. Within the linear zone the response of the valve-cylinder combination is given by the loop transfer function

$$\frac{y}{e} = Y(D) \qquad (1)$$

where $Y(D)$ is an algebraic function of the differential operator $D \equiv d/dt$. The axial valve force is given by

$$F(e') = k(e_0 - x) \qquad (2)$$

where e_0 is the initial valve displacement, *Fig.* 4. Combining Equations 1 and 2, a differential Equation in terms of e, the valve opening, can be obtained:

$$[1 + Y(D)]\, e + \phi(e') = e_0 \qquad (3)$$

where $\phi(e') = F(e')/k$.

Since $\phi(e')$ does not vary linearly with valve velocity, e', an approximate method must be adopted for the solution of Equation 3. The method chosen is an application of the calculus of finite differences [4,5], whereby $e(t)$ is expressed in terms of successive values e_0, e_1, e_2 . . ., *Fig.* 5, after short intervals of time, δ, as follows:

Fig. 2—Below—Performance characteristic of the servomechanism of *Fig.* 1 during one valve opening and closing cycle

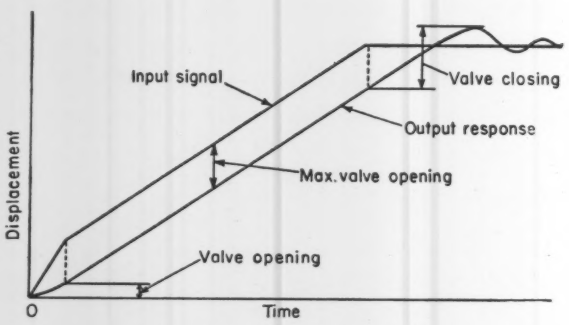
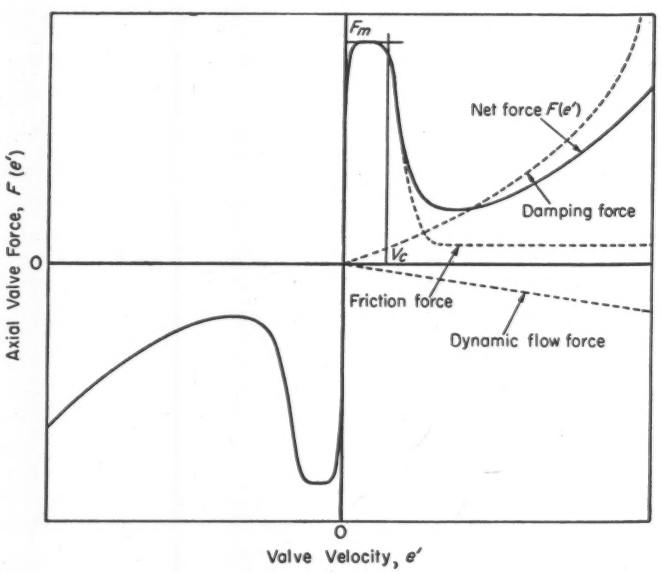


Fig. 3 — Right — Typical variation of axial valve forces with valve velocity



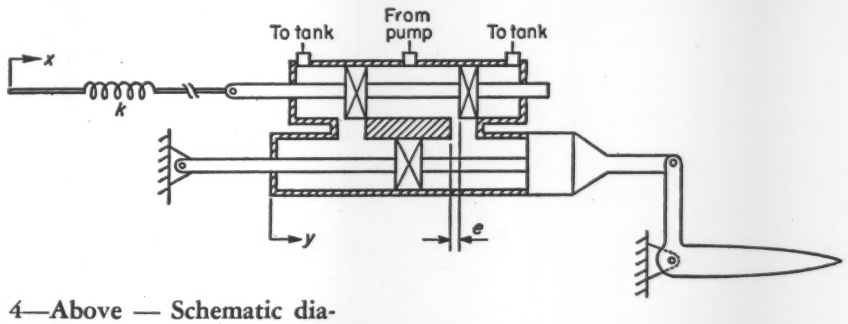


Fig. 4—Above — Schematic diagram relating input stiffness k, valve opening, e and output y

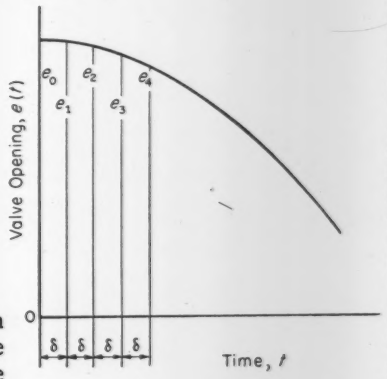


Fig. 5—Right—Graphical representation of method employed to evaluate valve opening, e, with respect to time

$$e = e_0 + e_1 E^{-1} + e_2 E^{-2} + \ldots \quad (4)$$

where e_n is the value of $e(t)$ at time $t = n\delta$, and E is the shift operator, such that $Ee_n = e_{n+1}$. Similarly $\phi(e')$ must be expressed in the form

$$\phi = \phi_0 + \phi_1 E^{-1} + \phi_2 E^{-2} + \ldots \quad (5)$$

where ϕ_n is the value of $\phi(e')$ at time $t = n\delta$.

In order to express the operator $1 + Y(D)$ in terms of the shift operator, E, a useful relationship must be found between the differential operator, D, and the shift operator, E. Tustin[4] has suggested that the expression

$$\frac{2}{\delta}\left(\frac{1 - E^{-1}}{1 + E^{-1}}\right)$$

can be used with reasonable accuracy to represent D, and substituting this relation in $1 + Y(D)$ an algebraic function of E^{-1} is obtained.

A simple example will demonstrate the step-by-step technique which has been used to solve Equation 3. Suppose $Y(D)$ denotes a simple integration, that is

$$Y(D) \equiv \frac{\mu}{D} \quad (6)$$

Then Equation 3 becomes

$$\left(1 + \frac{\mu}{d}\right) e + \phi(e') = e_0 \quad (7)$$

Substituting for e, ϕ, and D in terms of the shift operator E

$$\left[1 + \frac{\mu\delta}{2}\left(\frac{1 - E^{-1}}{1 + E^{-1}}\right)\right](e_0 + e_1 E^{-1} + e_2 E^{-2} + \ldots) + (\phi_0 + \phi_1 E^{-1} + \ldots) = e_0 + e_0 E^{-1} \ldots \quad (8)$$

Expanding in powers of E^{-1} and collecting coefficients of like powers the following relations are obtained:

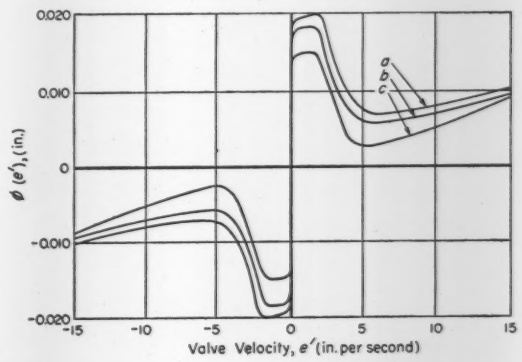
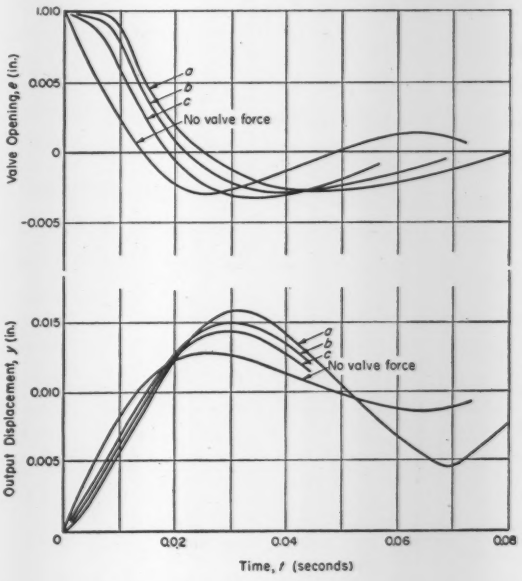


Fig. 6—Above—Characteristic relationships of valve velocity e' to function $\phi(e')$ for different axial valve forces denoted by a, b and c

Fig. 7—Below—Effect of different values of axial valve force upon valve opening e and output displacement y versus time t



$$\left.\begin{aligned}\phi_0 &= -\frac{\mu\delta}{2}e_0\\ \phi_1 &= (1-\mu\delta)e_0 - \left(1+\frac{\mu\delta}{2}\right)e_1\\ \phi_2 &= (1-\mu\delta)e_0 - \mu\delta\, e_1 - \left(1+\frac{\mu\delta}{2}\right)e_2\end{aligned}\right\} \quad \ldots\ldots (9)$$

The interval of time chosen must be small compared with the time constant of the servo, say $\delta = 1/10\mu$. Hence

$$\left.\begin{aligned}\phi_0 &= -0.05e_0\\ \phi_1 &= 0.90e_0 - 1.05e_1\\ \phi_2 &= 0.90e_0 - 0.10e_1 - 1.05e_2\end{aligned}\right\} \quad \ldots\ldots (10)$$

Since e_0, the initial valve opening, is known ϕ_0 can be found. The procedure now is to guess a value for e_1, which allows a speculative ϕ_1 to be calculated from Equation 10. However, e_1 can be found approximately from the values of e_0 and e_1 either by using the expression for the differential operator, or more conveniently by graphical differentiation. From the curve of ϕ against e' the corresponding value of ϕ_1 can be found. The two values of ϕ_1 thus obtained should concur for an accurate guess of e_1. In a like manner e_2 can be obtained from e_1 and so on.

Example: No general conclusions can be formulated, since results depend on the characteristics of the servo involved and on the form of the axial valve forces, but the following example has been worked to illustrate the adverse effect which might occur.

The transfer function of the servo considered is

$$Y(D) = \frac{\mu}{D(1+TD)}$$

where $\mu = 100$ and $T = 0.010$ second. The axial valve forces and the stiffness of the input circuit are characterized by the series of curves of $\phi(e')$ plotted against e' in *Fig.* 6. *Fig.* 7 shows how the valve opening and the servo output vary with time when the system is given a step input of 0.100 inch. They are compared with like responses calculated for the same control system in the absence of any axial valve forces. The very marked increase in oscillation when large valve forces are present is apparent.

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Welded Design Improves Rear Axle

RELATIVELY simple changes in design can often result in marked improvement in an assembly. An example of this is found in a three-piece rear axle assembly for 15 and 30-ton capacity off-the-highway dump trucks. Changing from bolted to welded assembly of this axle reduced cost by 40 per cent and weight by 23 per cent.

The original axle housing consisted of three low alloy steel castings, two identical spindle ends and a center section or banjo which were machine-faced and then drilled for bolting at the mating faces. A total of 22 high-tensile steel bolts with serrations under the heads were used to attach the spindle. Bolts were installed by driving with a sledge as no adequate power tool could be obtained. Self-locking nuts were driven on the bolts with a pneumatic tool and then tested to be sure that all nuts were tightened to a torque of 220-250 lb-ft. The testing required 12 minutes.

Difficulties were often encountered during the assembly of these axles. Slight misalignment of the bolt holes would cause bolts to fracture as others were being sledged into place. Another common difficulty was failure of the serrated bolts to fit snugly.

A redesigned rear axle, *Fig.* 1, substitutes two circumferential welds for the 22 bolts and nuts. Though still an assembly composed of essentially the same basic parts, elimination of the bolts permitted the heavy bolting flanges to be eliminated from banjo and spindles. This reduced banjo weight from 732 pounds to 572 pounds; weight of each spindle was reduced from 322 to 224 pounds. Since the spindle flanges also served as brake backing plates, backing plate assemblies of ⅜-inch plate are used with the welded axle. Assembly of the welded axle is performed in a fixture using air-operated rams to hold both spindles in proper position against the banjo with enough force to obviate the need for tack welds. Welding is performed by a single submerged arc welding head as the assembly rotates in the fixture. The head is repositioned to make the second weld.

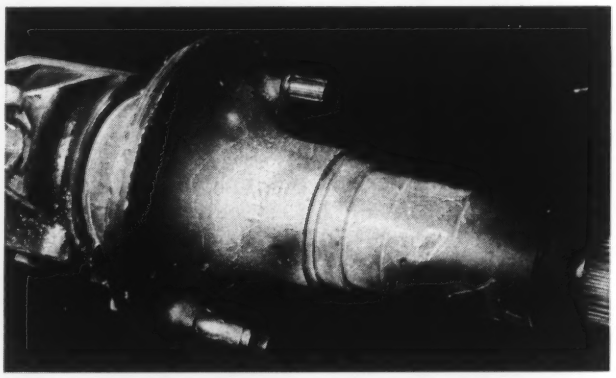


Fig. 1—Welded assembly offers appreciable savings in cost and weight. An interim model is shown here during tests to determine feasibility of this type of construction

From a paper receiving a Second Award in a Mechanical Design Award Program of the James F. Lincoln Welding Foundation by Martin M. Shaffer, supervisor, Manufacturing Development Dept., Euclid Div., General Motors Corp.

MECHANISMS FOR Uniform-Velocity Reciprocating Motion

By Paul Grodzinski
London, England

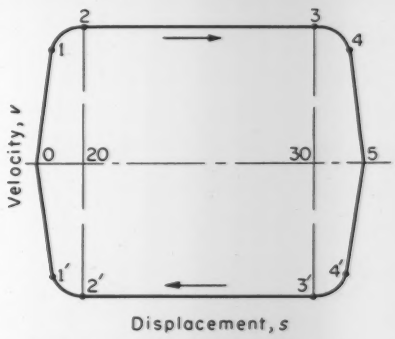


Fig. 1 — Velocity-displacement relationship desired of uniform-velocity reciprocating motion mechanisms. Motion is assumed to start at point 0, with acceleration to the constant velocity via points 1 and 2. Uniform velocity occurs between points 2 and 3, and deceleration from 3 to 5. The return stroke is assumed to be identical

SPECIAL-PURPOSE mechanisms, once known and evaluated, offer convenience of choice in design without need for a new and detailed search. Mechanisms giving straight-line motion outputs, for example, have been listed and analyzed. This article explores another such special-purpose-group—mechanisms for constant-velocity reciprocating motion. Processes such as grinding and polishing, which prompted investigations and developments discussed here, are typical of applications where uniform-velocity reciprocation, along a straight line or along an arc, may be required.

Straight-Line Constant Velocity: The general idealized form of stroke-velocity character required is shown in *Fig.* 1. Such an output from a standard mechanism providing linear reciprocation usually can be realized only with a variable-velocity input. The nature of the input to the driving mechanism is best shown by a "hodagraph"—a polar diagram of angular position versus angular velocity. A hodagraph of uniform angular velocity, of course, is a circle.

CROSS-SLIDE MECHANISM: *Fig.* 2*a* shows superposed the desired displacement-velocity relationship, the corresponding input hodagraph, and for reference a polar diagram of constant angular velocity. The cross-slide mechanism itself, *Fig.* 2*b*, would have to be driven through a double universal joint.

CRANK and SLIDER MECHANISM: How a crank and slider mechanism can be adapted to uniform-velocity straight-line motion is shown in *Fig.* 3. For symmetry of the hodagraph, the slide must be

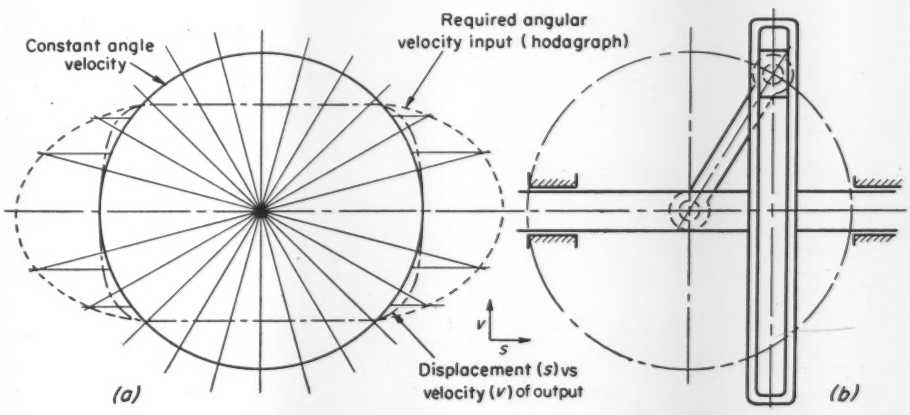


Fig. 2—At *a*, hodagraph for cross-slide mechanism, *b*, compared with polar diagram of constant angular velocity. The variable input velocity is that required to produce the superposed ideal displacement-velocity pattern also shown in *Fig.* 1

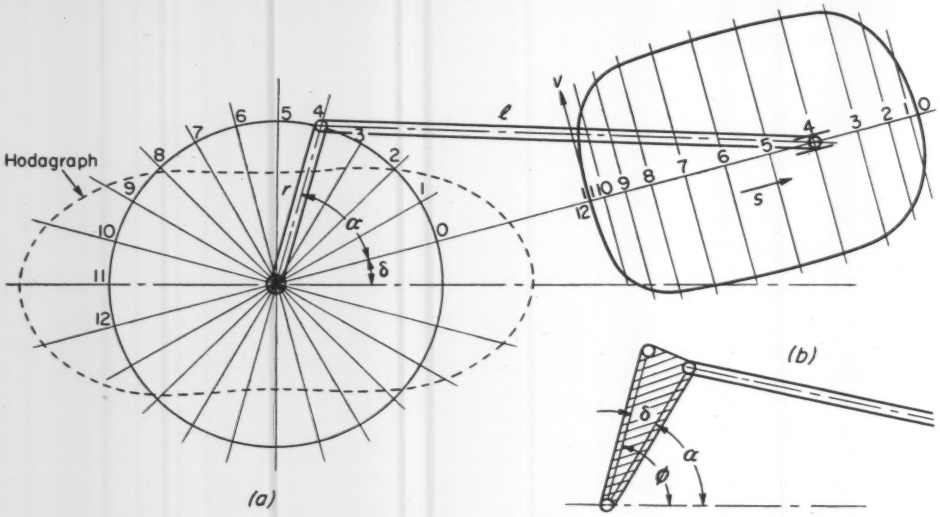


Fig. 3—Left—Crank and slider mechanism, *a*, with its hodagraph required for the ideal displacement - velocity diagram plotted on the slide axis. A phase correction, angle δ, must be introduced as shown in *a* or *b*

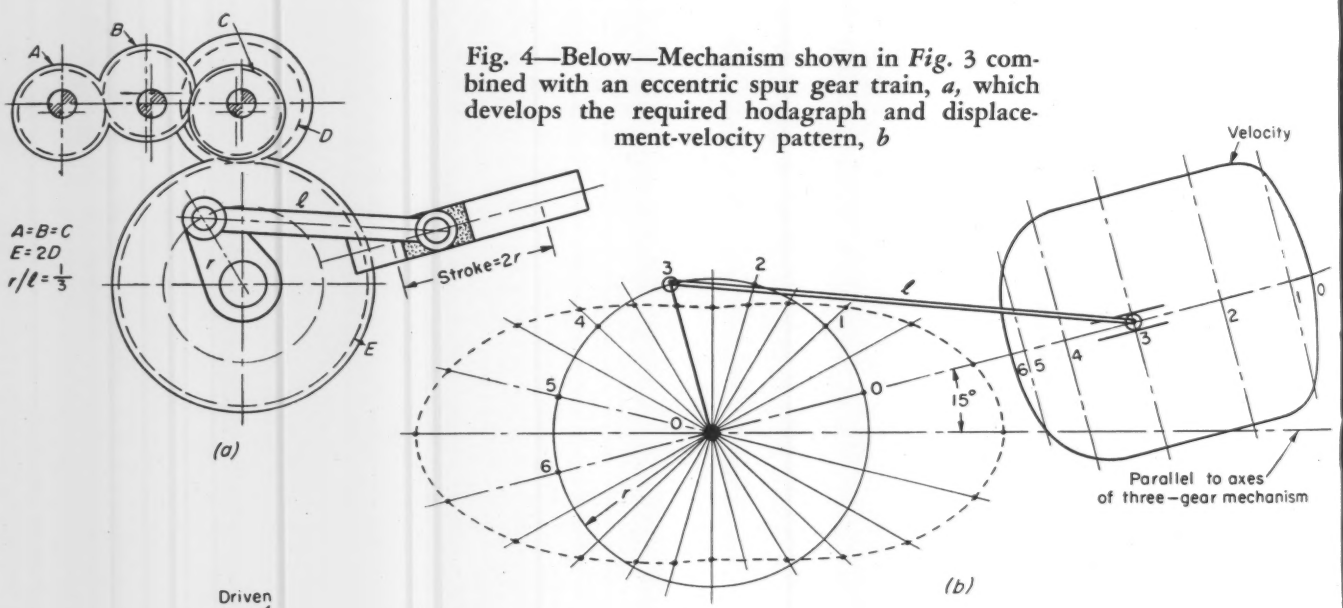


Fig. 4—Below—Mechanism shown in *Fig.* 3 combined with an eccentric spur gear train, *a*, which develops the required hodagraph and displacement-velocity pattern, *b*

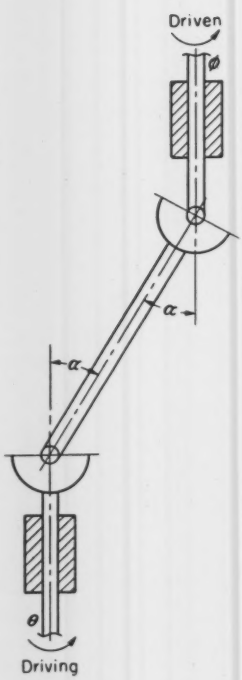


Fig. 5—Left — Universal joint (Hooke or Cardan) arrangement. Velocity variations in such joints, usually undesirable, can be employed to generate desired hodagraphs for uniform-velocity reciprocation

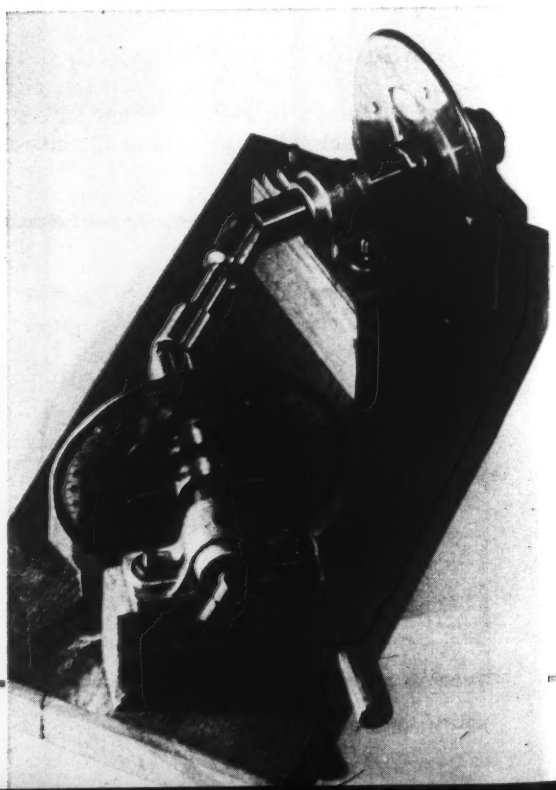


Fig. 6—Right — Model of joint arrangement similar to *Fig.* 5 except that axes are nonparallel to accentuate velocity variations

inclined at some angle (δ), *Fig. 3a*, or a phase displacement (δ) must be introduced between the crank on the hodagraph and the crank driving the slide, *Fig. 3b*. For example, uniform velocity is obtained in the crank rotation range of 45 to 135 degrees with $\delta = 15$ degrees when $r/l = 1/3$, where r = crank radius and l = rod length.

Within this same range of crank rotation and for the assumed displacement-velocity relationship, *Fig. 1*, angle δ can be calculated for any desired ratio, r/l. By derivation involving the acceleration in a centric crank mechanism and a demonstration that certain trigonometric relationships can be maintained nearly constant over the range of 45 to 135 degrees, the following approximate equation can be developed for fractional values of r/l:

$$\sin \delta = \frac{r}{l}\left[1 - 2\left(\frac{r}{l}\right)^2 + 4\left(\frac{r}{l}\right)^4\right]$$

Generally, variations over the range intended to be constant will not exceed ± 5 per cent.

ECCENTRIC-GEAR DRIVE: Combination of eccentric spur gears, *Fig. 4a*, produces cyclical variations in

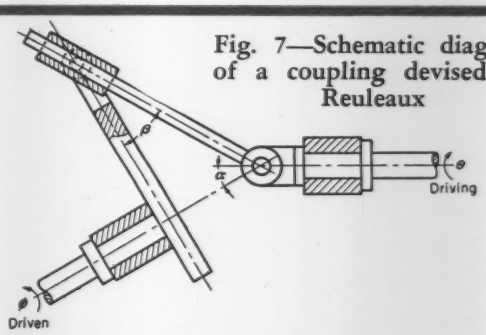


Fig. 7—Schematic diagram of a coupling devised by Reuleaux

Fig. 8—Left — Model of Reuleaux mechanism sketched in *Fig. 7*

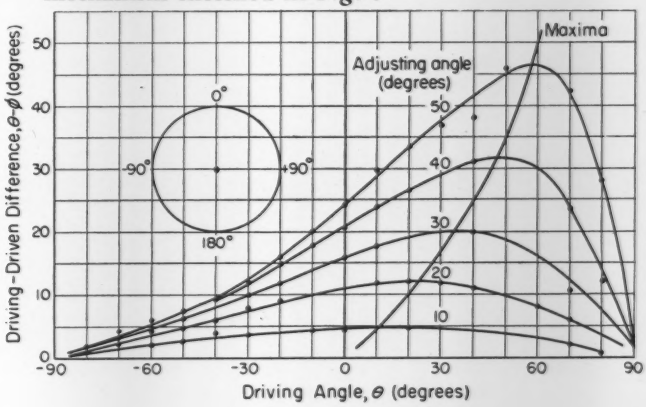


Fig. 9—Above — Graph showing differences in velocity of driving and driven shafts of Reuleaux mechanism

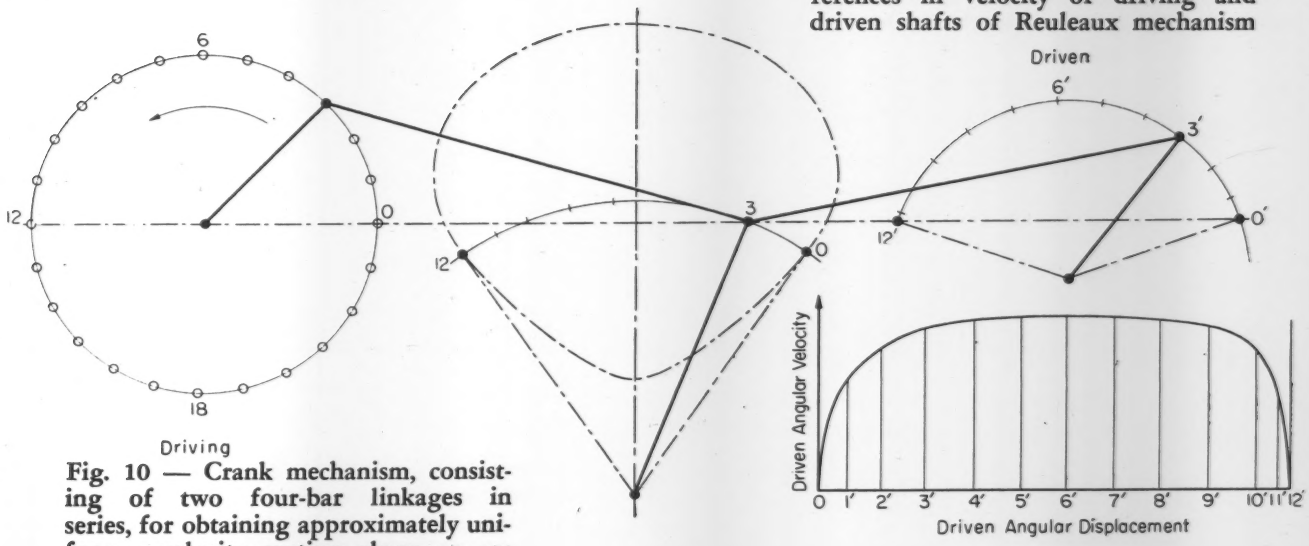


Fig. 10 — Crank mechanism, consisting of two four-bar linkages in series, for obtaining approximately uniform - velocity motion along an arc

angular velocity, and a hodagraph of extended elliptical form, *Fig.* 4*b*, can be obtained by a gear reduction of 1 to 2 between the output of the eccentric set (gears *A* to *D*) and the crank (gear *E*). In *Fig.* 4*b*, if the slide is replaced by an arc, an arc motion with uniform angular velocity results.

A straight-line version of this mechanism has been constructed. With the gear train running in an oil bath, satisfactory operation to 300 strokes per minute has been obtained.

UNIVERSAL JOINTS: During one complete revolution, a single universal joint (Hooke or Cardan) has two maxima and two minima of angular velocity. In many applications, this characteristic is a serious disadvantage and is eliminated by the use of a second joint in a mirrorlike arrangement. However, this same characteristic can be used to produce a hodagraph of the type shown in *Fig.* 1 for the driving of a cross-slide or a crank and slider mechanism.

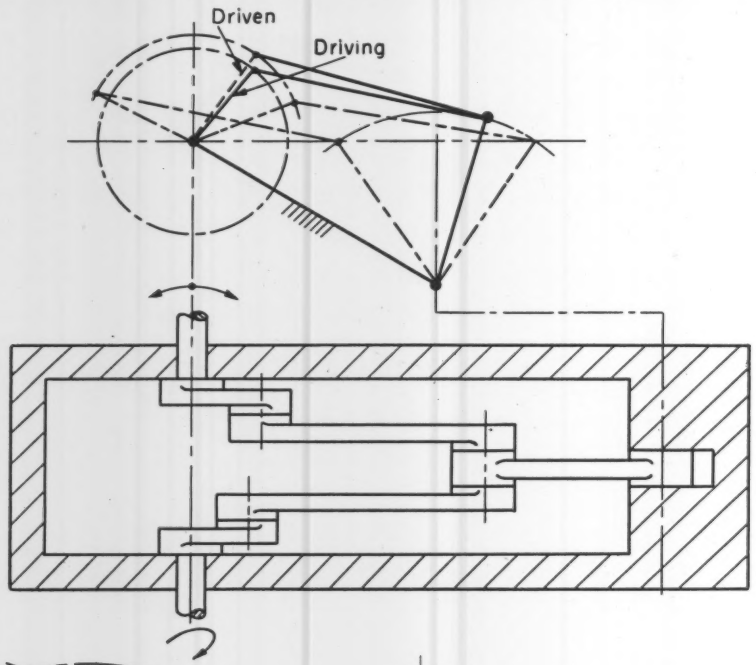


Fig. 11—A reverting arrangement of the design shown in *Fig.* 10

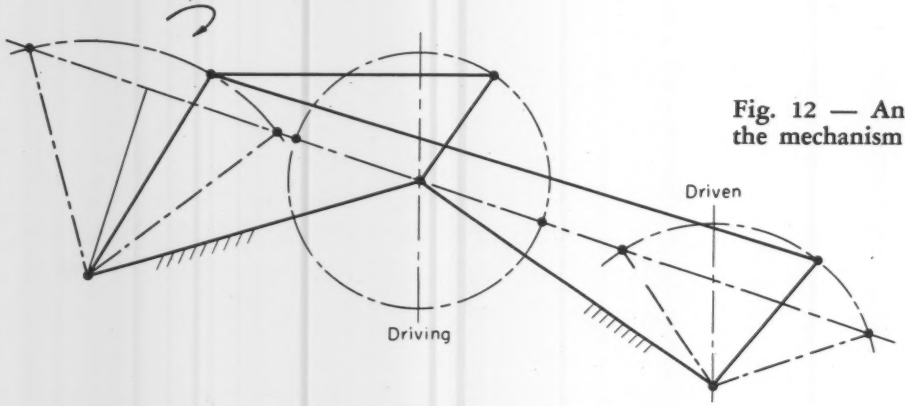


Fig. 12 — Another variation of the mechanism shown in *Fig.* 10

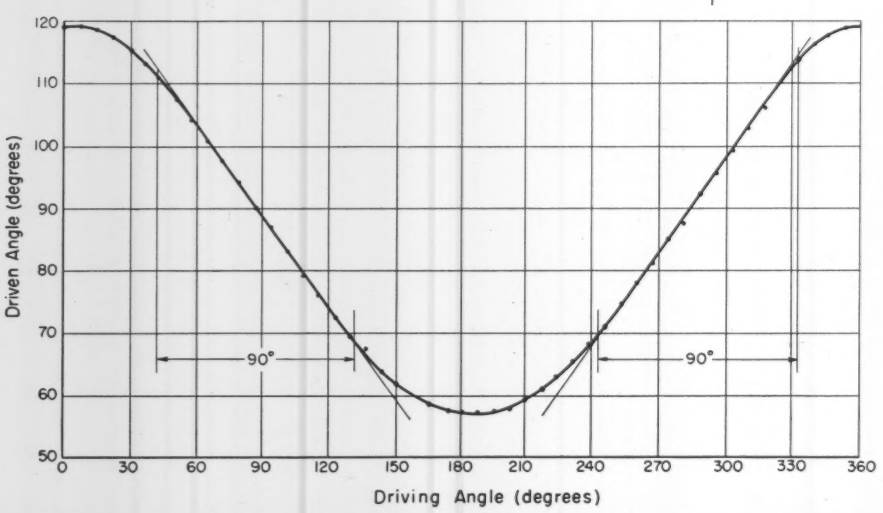


Fig. 13—A graph of input-output displacements of the mechanism in *Fig.* 10 showing that essentially constant - velocity motion can be obtained over 90-degree angles of driving-crank rotation

An analysis has shown that the best solution is to use two joints which give the further advantage of parallel driving and driven shafts, *Fig.* 5. For accentuation of the velocity variability, the input and output shafts can be arranged in nonparallel fashion, *Fig.* 6. Experiments with the model shown in *Fig.* 6 revealed that a suitable hodagraph could be obtained with angle α at each joint equal to 55 degrees. Accurate theoretical analysis of the problem proved difficult.

REULEAUX MECHANISM: Reuleaux described a link coupling he devised, *Fig.* 7, stating that the movement is much less uniform than with a conventional universal joint. Since this fault is the advantage required here, a model was constructed, *Fig.* 8, and an analysis conducted, *Fig.* 9. To permit adjustment of angle β, an additional link was introduced. The results shown in *Fig.* 9, however, were obtained with β fixed at 30 degrees.

Arc Motions: Although heart-shape cams are frequently used to obtain approximately uniform-velocity reciprocating motion along an arc, a number of linkage solutions can also be developed. One such arrangement is shown in *Fig.* 10 along with the type of displacement-velocity curve that can be obtained.

A number of modifications of this linkage become obvious. The center of the swinging driven member can be reverted to the center of the driving crank, *Fig.* 11. In this coaxial mechanism, a uniform rotational speed is imparted to one side, and from the other reciprocating motion of approximately uniform angular velocity is derived.

Still another physical arrangement of two four-bar linkages in series is shown in *Fig.* 12. An experimental model of this version produced the experimental results shown in *Fig.* 13.

The possibilities of converting reciprocating arc motion to reciprocating straight-line motion by the use of a rack and pinion are quite evident. One problem in linkage solutions is the difficulty encountered in establishing the required dimensions of links and center locations. However, this difficulty is being relieved to some extent by improved methods for layout of linkages.

CONTEMPORARY DESIGN

Pressure Testing Machine

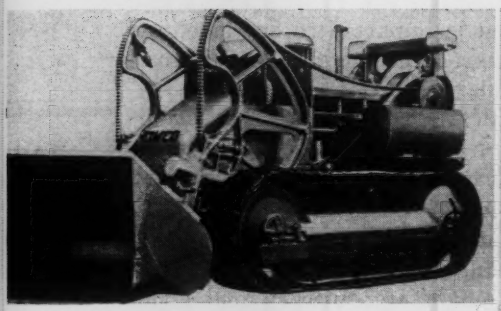
A NEW line of vertical pressure testing machines detects and locate leaks in castings, brazed, welded and soldered assemblies. Air-operated and electrically controlled, the machines subject parts to a 10-second automatic check in which the part or a specified area in the part is charged with a given volume of air. Loss of air pressure, indicating a leak or flaws, is indicated by signal lights through a sensitive measuring system. One machine, for example, tests a rifle grenade assembly fabricated by soldering together several spun copper parts. Four test stations are provided to permit testing four grenades at a time; two stations are unloaded and loaded while two are checking.

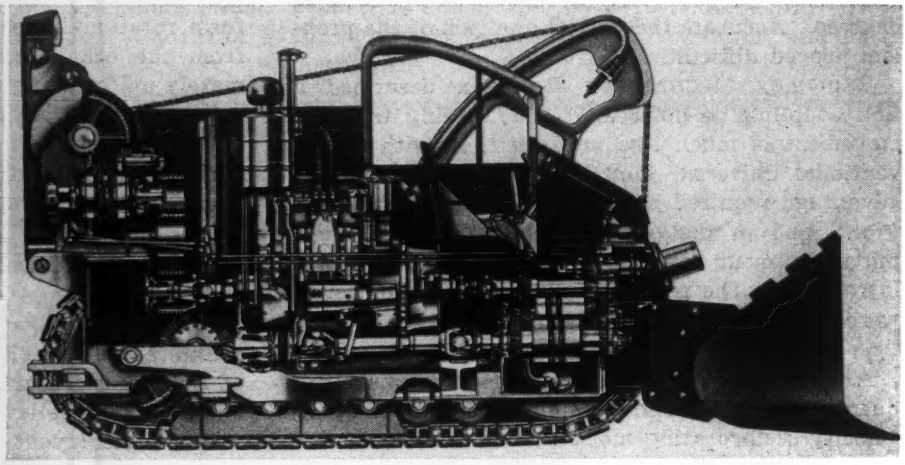
Three signal lights indicating the result of the pressure test are located under each station. Two of the signal lights locate leaks in the grenade soldered joints by indicating whether the leak is between chambers or to the atmosphere. The other indicates approved parts.

In operation, two stations are loaded by placing the grenades in rubber-faced spring clamp jaws. Air cylinders above the station lower a clamping head, sealing both ends of the parts for the test operation. Build-up of pressure in the clamping cylinder when the grenade is securely clamped causes the two test cycles to start automatically.

Of welded steel construction and weighing about 800 pounds, the pressure testing machine was built by Hautau Engineering Co.

New Transmission Design Improves Tractor–Loader

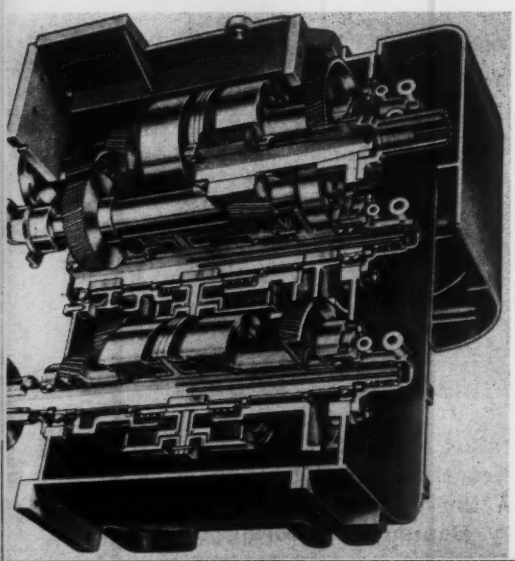




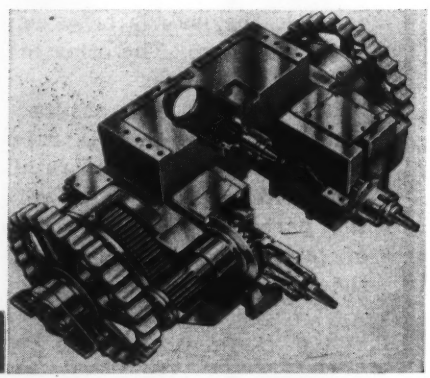
CONSIDERABLY heavier than previous models (34,000 pounds complete with loader), the new model 105 prime mover developed by the Eimco Corp. has a new transmission containing all gearing and clutches for speed changing and full, independent reversal of each track in one compact unit. All foot clutches and manual gear shifting have been eliminated, and immediate reversal or speed changing under full power are possible while in motion. The power unit, a 90-horsepower diesel with a matched torque converter, faces the rear. A power takeoff on the front of the engine drives the rocker-arm loader through a two-speed transmission of the same general type as for the tractor.

Independent drive for each track, both forward and reverse, is achieved by a combination of hydraulically actuated friction clutches and constant-mesh helical gearing housed in one compact case at the front of the machine. Forward and reverse speeds of 0 to 2 mph are possible in low gear; high-gear speed is 0 to 5 mph. Since each track is controlled independently, "spin" turns are possible by reversing the direction of one track, or a "feathered" turn by leaving one track in neutral. Forward and reverse track control is concentrated in two handles for operation by one hand; forward or reverse drive results from a push or pull on both handles, and twisting the levers produces a spin turn. Both controls automatically return to neutral if released.

Additionally, a conventional turn may be made with the track brakes, which are of the air-cooled disk-type—although these brakes are intended mostly for parking. An additional brake for bucket control is of the same type.



Final drive cases, having no clutches, brakes or complicated assemblies, are separated by a spacer piece which is the housing for the rear power takeoff. If wider or narrower gage tractor units are desired, this housing is one of the few pieces which must be changed. The final drive case, and other parts such as the transmission case and covers, are cast alloy or fabricated wrought steel. All gearing, sprockets, front idlers and many other parts of cast alloy steel are liquid flame hardened—and are believed to be the first so produced on a commercial basis.



DESIGNING BUILT-IN LIGHTING FOR MACHINES

Improved operation, efficiency, appearance and customer acceptance can be attained by providing adequate illumination and reliable visual signaling and indication

By Robert C. Rodgers
Assistant Editor, Machine Design

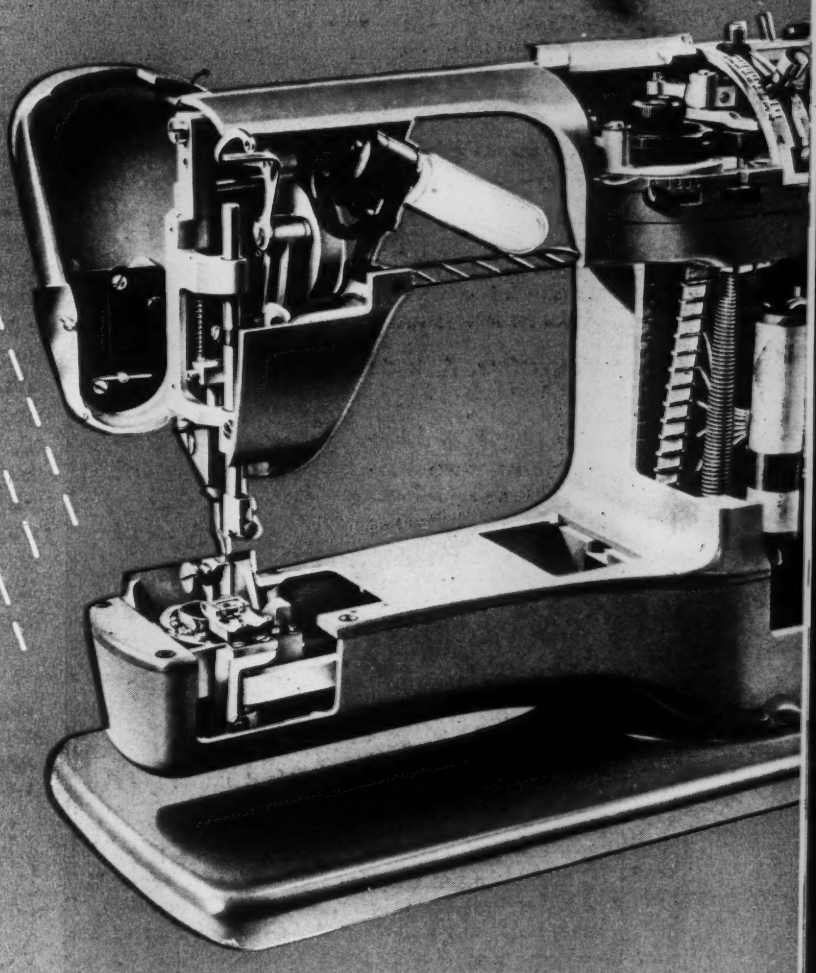


Fig. 1—Basic shape of this sewing machine was used to advantage to neatly build-in a light. Lamp socket and scissors guard are made as a single unit which hinges on a pin for easy lamp maintenance

TREMENDOUSLY improved lighting in machines today has been achieved largely through increased attention in initial design planning. Ideal lighting conditions today are limited only by knowledge of seeing and basic design factors concerning light and its control. To most effectively design lighting equipment into a particular machine, careful evaluation of the seeing requirements must be made in order to obtain light with the proper color, brilliance, and directional distribution characteristics most suitable for the operating conditions, *Fig.* 1. Lighting considerations and limitations are quite different for a sewing machine than for built-in landing lights in a helicopter. Engineered lighting offers the most satisfactory results in all cases.

In effectively integrating lighting with machines, the application of light for visual indication should also be considered. This important use is included in design of a majority of mechanical units manufactured today. In this function, signal and pilot lights permit quick observation of conditions in a machine at the many points that are vital to proper operation.

Need for Good Lighting: In modern machines, whether data computers or jet fighters, the complexity of details that must be seen day or night has greatly increased. However, speed and accuracy of seeing are expected to remain at least at the same level and in many instances must be increased also. The most effective way to meet these demanding requirements, of course, is to improve seeing conditions with well-designed lighting. This calls for serious consideration of the amount of light required for assuring highest efficiency with the human link in machine control.

Visual and lighting research throughout this country and abroad has indicated the desirability of 50 to 2000 footcandles of illumination for various jobs in order to obtain maximum human efficiency along with minimum fatigue; specific illumination values depend upon individual seeing requirements and limitations.

In many indoor and outdoor work areas it is usually not practical or economical to obtain illumination values much above 100 footcandles from lighting systems mounted on ceilings, walls, poles, etc. In fact, many general lighting systems still exist in

homes, stores, garages, offices, laboratories, factories, etc., that provide only 5 to 20 footcandles on horizontal work surfaces; of course, only a fraction of that amount can illuminate inclined, vertical, and interior parts of machines used in such areas.

Therefore, besides assuring adequate light for proper machine operation and maintenance, built-in lighting makes it possible to provide additional illumination in quantities from 50 to 2000 footcandles on any desired machine work plane in an easy and economical manner.

Of course, millions of machines in the transportation field (automobiles, trains, airplanes, etc.) and in the ordnance, agricultural, construction, and mining machinery field could not operate effectively under all service conditions without built-in lighting.

Benefits of Built-in Lighting: In industrial machinery, for example, properly designed built-in lighting can provide greater operator convenience; dangling or excessively protruding "hung-on" lighting equipment may actually hinder more than the added light can help. The vertical milling machine shown in *Fig.* 2 has lighting units neatly recessed into the framework—there are no protruding lighting fixtures to obstruct operations yet plenty of light is provided on the machining area. Whether built into industrial machinery, office machines, airliners, or home appliances, good lighting means comfortable lighting. In addition to the basic advantages mentioned, well-designed built-in lighting invariably results in greatly improved appearance and customer acceptance, *Fig.* 3. Also, many

Basic Lighting Terms and Equations

Luminous Intensity or candlepower, I, is flux density of a light source in a specified direction and is measured in *candles* (c).

Luminous flux, F, is time rate of light flow and is measured in *lumens* (lm).

Illumination, E, is density of luminous flux incident upon an object or surface and is measured in *footcandles* (ft-c).

$$E = I \cos \theta / D^2$$

where θ is angle between normal to surface and direction of incident light, D is distance from light source to work surface in feet. Equation applies strictly only to a point source, but reasonable accuracy is obtained if D is five to ten times maximum source dimension. Also,

$$E = F/A$$

where A is area in square feet uniformly illuminated.

Brightness, B, is amount of light flux reflected or emitted from a surface in a given direction per unit of projected area. Measured in *candles per square inch* (c/in.^{2}) or more commonly in *footlamberts* (ft-L).

$$B = ER \text{ or } ET$$

where R is the diffuse reflection factor of a material and T is the transmission factor of a material in per cent.

Fig. 2—Below—Milling machine equipped with two built-in lighting fixtures containing standard voltage lamps. Holes for fixtures were cored when head was cast. Plastic fixture covers protect lamps from dust, dirt, and flying metal

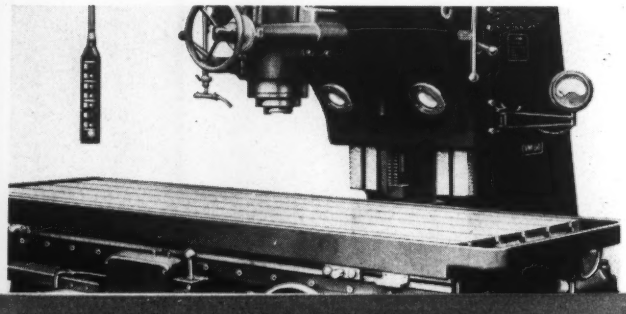
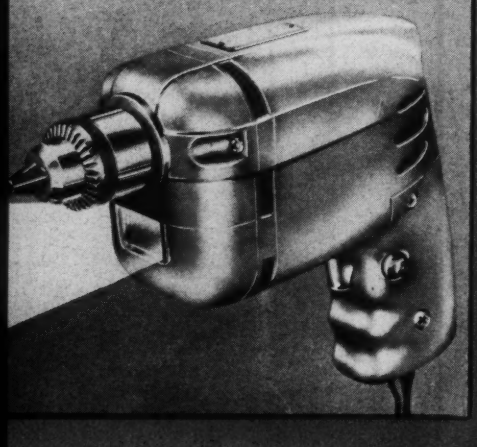


Fig. 3—Left—Besides providing handy illumination, this drill light is lit continuously if cord is plugged-in thus warning operator to exercise handling precautions. Lamp is protected from impact and vibration by mounting socket in soft plastic. Openings in plastic shield permit lamp ventilation



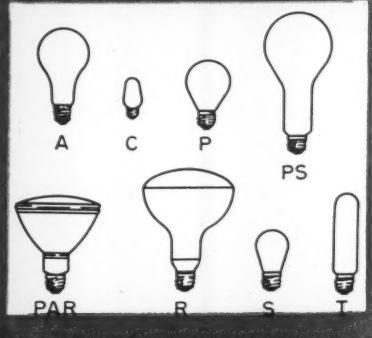


Fig. 4—Bulb shapes commonly employed in machine lighting and standard bulb designations

benefits such as increased safety, operator care and handling, operating speed and accuracy, etc., can accrue.

Design for Lighting: Since properly designed lighting requires a knowledge of light itself and the theory of illumination, certain basic data must be considered and evaluated. This article will seek to bring into focus for the machine designer pertinent background data and outline specific steps in the process of designing for the most economical, practical and effective built-in lighting.

LIGHT SOURCES

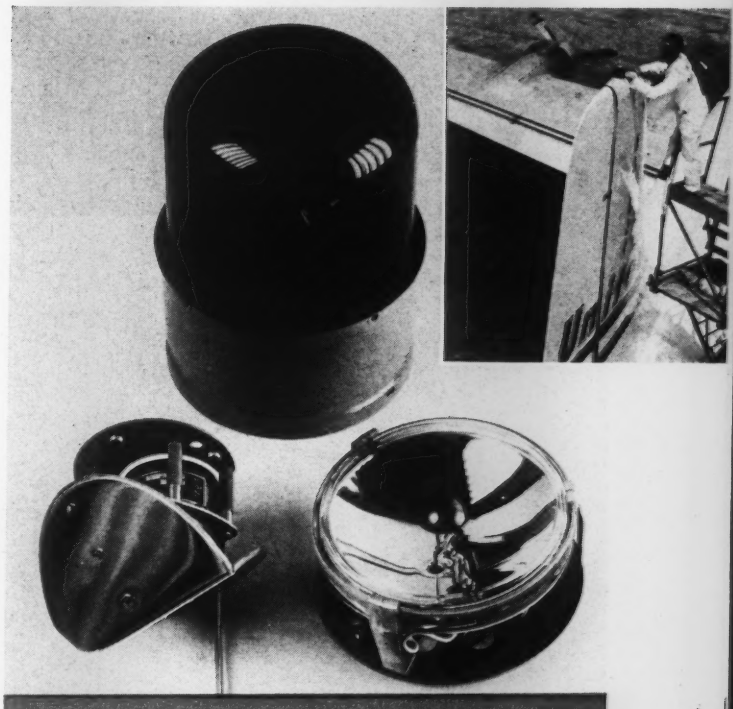
Selection of the right lamp for a specific application is one of the most important decisions to be made in the design of built-in lighting. There are many lamps that could possibly be employed on a certain machine and it is sometimes difficult to choose the particular lamp that is superior in every respect when all design features and limitations are taken into consideration. Many special shape, voltage, and wattage lamps are manufactured, but the designer is wise to select a light source that is commonly available, provided it meets the design requirements satisfactorily. This is obviously true not only because such a lamp is easy to obtain for replacement purposes but it will be more economical to buy.

Three basic light sources commonly available are the incandescent, gaseous discharge, and fluorescent. Electroluminescence is a relatively new basic light source that shows promise.

Incandescent Lamps: Often referred to as tungsten filament lamps, these light sources are produced in literally hundreds of sizes, shapes, colors, and wattages. They are designed for voltages as low as 1 volt or as high as 300 volts. Wattages for these light sources range from less than 0.1-watt to 50,000 watts. Some of the more common bulb shapes for these lamps are outlined in *Fig.* 4 along with standardized bulb designations.

Incandescent lamps have many desirable features along with several drawbacks. Briefly these are some of their advantages:

1. Commonly available and inexpensive.
2. Simple to install and maintain—no ballasts or starters needed.
3. Designed for wide voltage range.
4. Efficient at low voltages.
5. Rugged at low voltages.
6. Operate well on either ac or dc.
7. Concentrated light source permitting ease in light control.
8. Air temperature and circulation has little effect on light output.
9. Start reliably at any temperature.
10. Lamp life unaffected by intermittent duty.



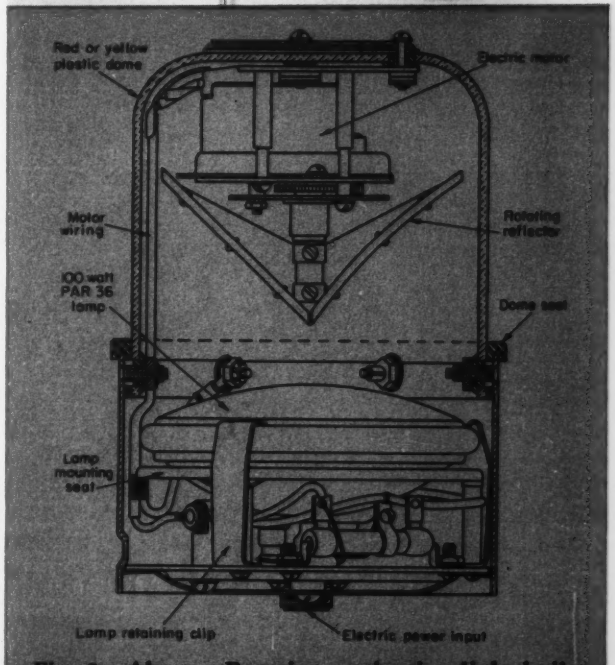


Fig. 5—Above—Rotating navigation light built into tail of airliner. Components employed in unit are shown in cross-section. Since light is used only during flight, high-speed air keeps unit cool

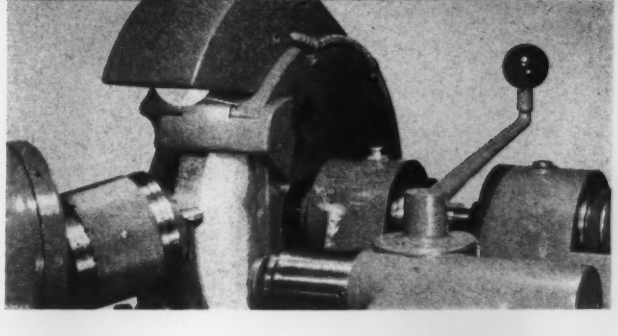


Fig. 6—Below—Inside-frost 25-watt A bulb built into twist-drill grinding machine

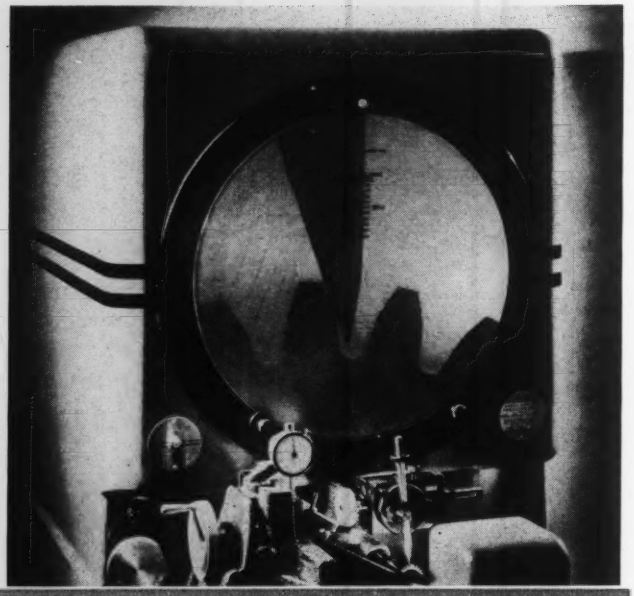


Fig. 7—Accurate control of light is afforded with picture protection lamp in this optical gear analyzer

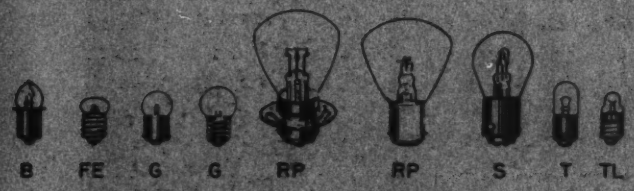


Fig. 8—Above—Bases and bulb shapes of typical incandescent miniature lamps and standard bulb-shape designations

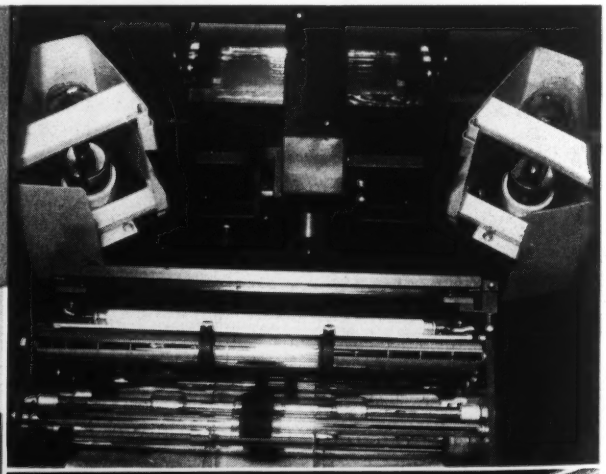
Shortcomings of incandescent lamps are important to the designer. Some of their disadvantages may call for the selection of a fluorescent lamp or some other basic type of lamp. The following drawbacks are most prominent:

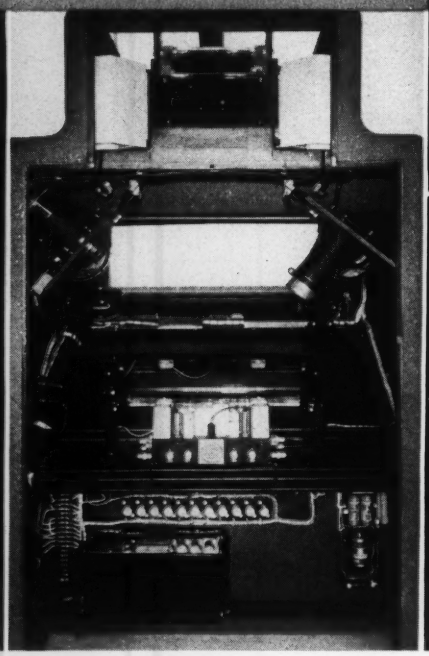
1. Low efficiency at standard voltages in comparison to same wattage mercury vapor or fluorescent lamps.
2. High heat generation.
3. Fragile filaments in higher voltages unless specially mounted.
4. Short life—usually 750 to 2000 hours.
5. High brightness.

Sources that are high in brightness are somewhat desirable in visual indication lamps but not for comfort in illumination; high-brightness sources require extra care in shielding.

GENERAL-SERVICE LAMPS: The most commonly used incandescent lamps are in the 60 and 100-watt size A bulbs. The PS designated lamps start at the 200-watt size and both A and PS lamps are available in clear and inside frosted bulbs. Clear bulbs are employed in locations where accurate control of light is desired and, of course, the clear bulb assures maximum light transfer from the lamp. Inside frosting of lamps helps reduce glare and eliminates filament striations and shadows, yet it absorbs only 1 to 1½ per cent of the light produced. Lamps in this class have a design life of 750 to 1000 hours.

REFLECTOR AND PROJECTOR LAMPS: Having bulbs made with special parabolic contours, these lamps





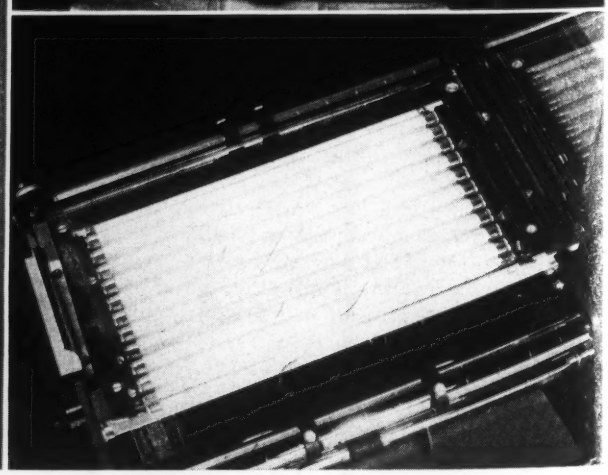


Fig. 9—Below—Two 250-watt mercury lamps illuminate opaque continuous-roll records or single-sheet records in this data analysis machine. Image of data is reflected through a compound lens and mirror to ground-glass viewing screen. Eleven 8-watt fluorescent lamps transilluminate semitransparent material. Forced-air cooling prevents execessive heat from damaging records or machine

provide high footcandle levels for floodlighting and spotlighting in industrial machinery, headlighting, automobiles and locomotives and many similar applications. Reflector (R bulb) lamps are made in either soft or heat-resisting glass. The latter type will withstand a limited amount of flying liquid without breaking. Projector lamps are made of pressed hard glass and have the PAR designation indicating a parabolic aluminized reflector.

The number following the letter of the bulb designation is the diameter of all lamps in eighths of an inch. For example, the lamp employed in the rotating navigation taillight assembly, *Fig.* 5, is a PAR 36, nominally 4½ inches in diameter.

ROUGH AND VIBRATION SERVICE LAMPS: Where a light source will be subject to excessive knocks and bumps it may be necessary to specify so-called rough-service lamps if an incandescent type is desirable. These are available in low, standard, and high voltages in the A and PS bulb shapes with sizes that range from 25 to 500 watts. However, they should not be employed if a general-service lamp will operate with reasonable reliability. Since the filament in the rough-service lamp is held by many more supports, the light output is roughly two-thirds that of the same wattage and voltage general-service lamp.

Vibration-service lamps are designed for use near heavy or high-speed machinery (*Fig.* 6), elevators, filling-station gasoline pumps and other vibration areas. Employing a special filament wire and filament mounting, this lamp is available in the 25 to 150 watt sizes. Although not as low in efficiency as the corresponding rough-service lamps, vibration-service lamps still show a heavy sacrifice in efficiency as compared with general-service lamps. They should be used only where justified by environmental conditions.

Vibration and shock often accompany each other and it may be difficult to distinguish between them. Sometimes only by actually trying each lamp in the machine can the proper lamp be determined. In general, rough-service lamps can be used where there are both shock and moderate vibration; for this combination the vibration service lamps are not recommended.

PICTURE PROJECTION LAMPS: Where bright beams of light must be accurately controlled, the picture projection lamp is often employed. These light sources find application not only in still and motion-picture projectors but in oscillographs, radiometers, spectrophotometers, colorimeters, and optical comparators such as the one shown in *Fig.* 7.

BAKE-OVEN LAMPS: These sources are made with a special basing cement which will withstand temperatures up to 550 F and other special features which permit their use in applications where high external temperatures prevail.

MINIATURE LAMPS: This classification includes low-wattage lamps used mostly as visual signals or indicators in instrument and control panels, telephone switchboards, power indicators in office machines, industrial machinery, and transportation equipment. These small lamps usually are designed for low voltages. Several common miniature incandescent lamps appear in *Fig.* 8.

Electric Discharge Lamps: Mercury, neon and argon are usually employed for producing light by gaseous conduction methods. Such lamps of interest to the machine designer are discussed in the following paragraphs.

MERCURY-VAPOR LAMPS: Because of their operating characteristics, mercury-vapor lamps are limited to relatively high-wattage sizes—100 to 3000 watts. Design life of these sources is from 1000 to 10,000 hours depending on the lamp and the number of hours per start. Having efficiencies ex-

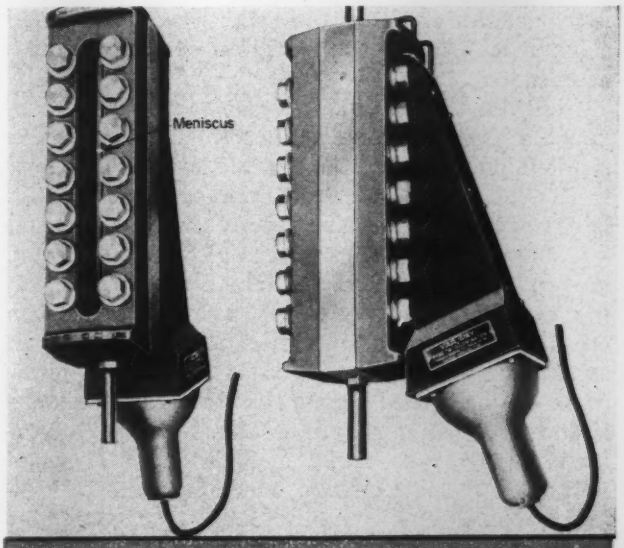
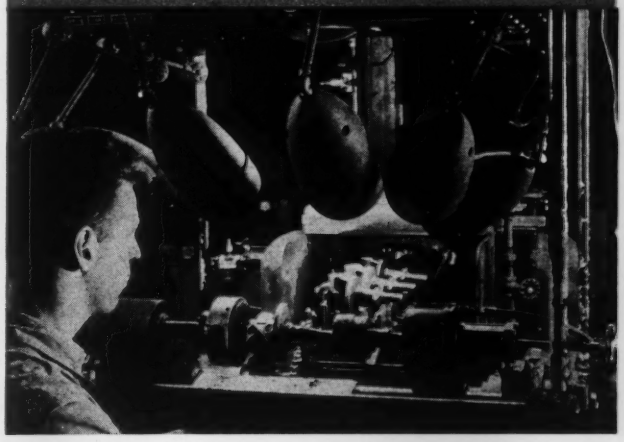


Fig. 10—Above—Meniscus of liquid-level gage is brilliantly illuminated with built-in 100-watt, PAR 38 mercury lamp. High brightness needed for distant viewing and television monitoring

Fig. 11—Below—Rough automotive forgings are checked under battery of six 250-watt, PAR 38 black-light spotlights in this semiautomatic inspection machine. As parts are picked up from conveyor and rotated, operator rejects those having fluorescent defect marks



ceeding 50 lumens per watt, mercury lamps can be used where high intensities of light are desired along with long life and economical operation, *Fig.* 9.

With the exception of fluorescent coated types, light from mercury lamps has a characteristic bluish-green color. When there is an absence of red radiation, most colored objects appear distorted in color value. Orange, pink, and red objects appear brownish or black. In the application of *Fig.* 9, the color of light was of little design importance since the main purpose of the machine is to measure and record data.

Where liquid-level gages such as shown in *Fig.* 10 are designed into machines and control panels, mercury lamps have been employed to light liquid meniscuses to high brightnesses. Lack of red light in mercury sources is used to advantage in water level gages because little light is reflected from rust particles and thus the brightness of the water column itself is low while brightness of meniscus is accentuated.

Ultraviolet light or so-called black light mercury lamps are widely employed in high-speed industrial semiautomatic inspection machines such as shown in *Fig.* 11. High-intensity, black light illumination is essential here for fast yet accurate observation.

GLOW LAMPS: Basically, the glow lamp consists of two electrodes inserted into a glass bulb containing one of the rare gases (neon, argon, helium, etc.). Various sizes and types of glow lamps are available ranging from 1/25 to 3 watts in power consumption. Since the light output of glow lamps is low, they find only limited use as sources of illumination; their major application is for visual indication purposes. Data computing and processing machines and counters, *Fig.* 12, employ glow lamps by the dozens for numerical indication because these lamps are rugged, reliable, require little power, and have very long life—some types are rated in excess of 25,000 hours.

Neon glow lamps radiate an orange-red light while argon glow lamps glow with a blue-violet color. Glow lamps, like all electric-discharge lamps, have a "runaway" characteristic and must be operated in series with some current-limiting device such as a resistor. Neon glow lamps can operate on voltages ranging from about 100 to 600 volts with the proper external resistors. Argon glow lamps produce considerably less light than neon lamps and have a much shorter useful life.

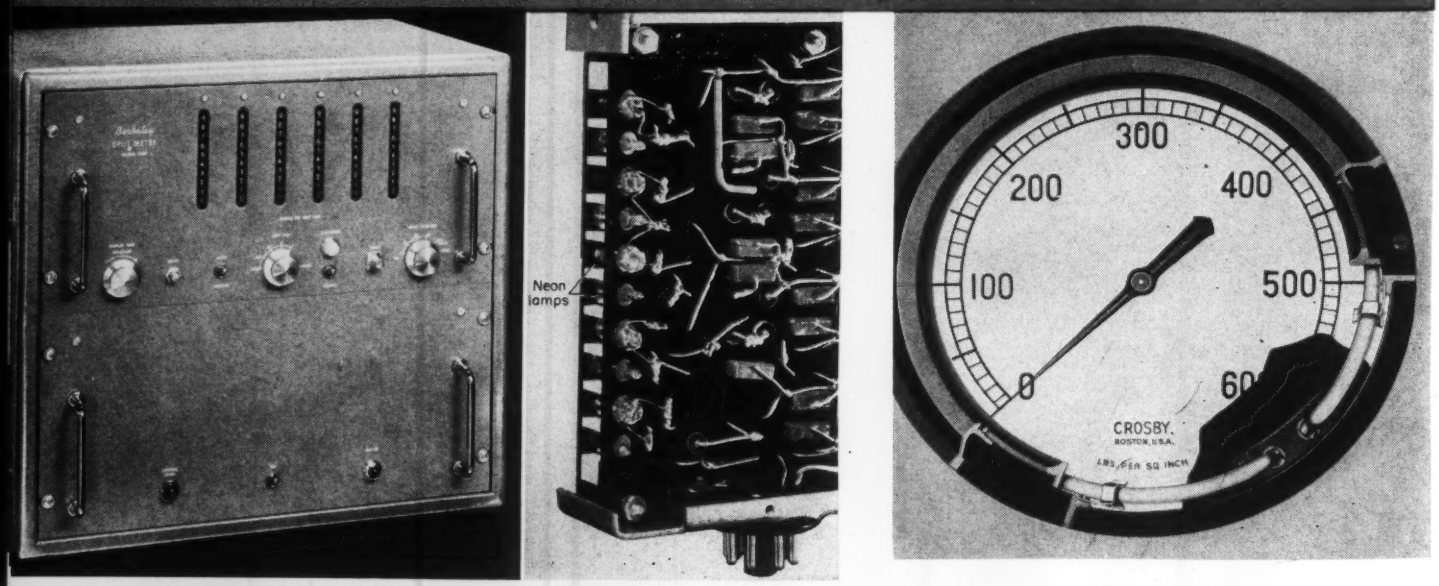
Response speed of glow lamps permits the light output to follow the current approximately linearly, up to flashing rates of 15,000 cycles per second. Glow-lamp characteristics are not noticeably affected by ambient temperatures below 300 F.

Fluorescent Lamps: For many machine lighting applications, fluorescent lamps should be given careful consideration. Nominal power ratings of these sources of light range from 4 to 100 watts. Made as straight tubes in sizes from 6 inches in length to 8 feet and in diameters which vary from $\frac{5}{8}$ to $2\frac{1}{8}$ inches, there is a fluorescent lamp available for practically any lineal space requirement. They are also produced in a number of circular forms. Where standard sizes fail to meet the designers space and shape limitations, custom-made fluorescent tubing designs can be specified such as employed in the pressure gage in *Fig.* 13.

Fluorescent lamps produce light about five times as efficiently as comparable-wattage, standard-voltage incandescent lamps. This lumens-per-watt efficiency advantage is offset by the fact that fluorescent auxiliaries (starters and ballasts) consume power, too, and fluorescent lamps and fix-

Fig. 12—Sixty little NE-2 neon lamps are employed to indicate count in events-per-unit-time instrument. Lamps are only 1/4-inch in diameter and slightly over 1-inch long and require minimal mounting space. Because of long life, lamps can be soldered in permanently

Fig. 13—Fluorescent tubing built into pressure gage provides evenly distributed light around dial. Tube is mounted in a reflector ring with spring clips. Three screws holding reflector simplify removal and maintenance



tures have a higher initial cost—often of importance to the designer and manufacturer. Major advantages of fluorescent lamps are:

1. High efficiency.
2. Low brightness.
3. Low heat generation.
4. Resistant to shock and vibration.
5. Long life—6000 to 10,000 hours.

Fluorescent lamps have disadvantages and the following would be of concern to the designer.

1. Complicated circuits and many components.
2. Do not operate on low voltage.
3. Do not operate too satisfactorily on dc.
4. Light output affected by air temperature and air circulation (*Fig.* 14).
5. Large in size for light output.

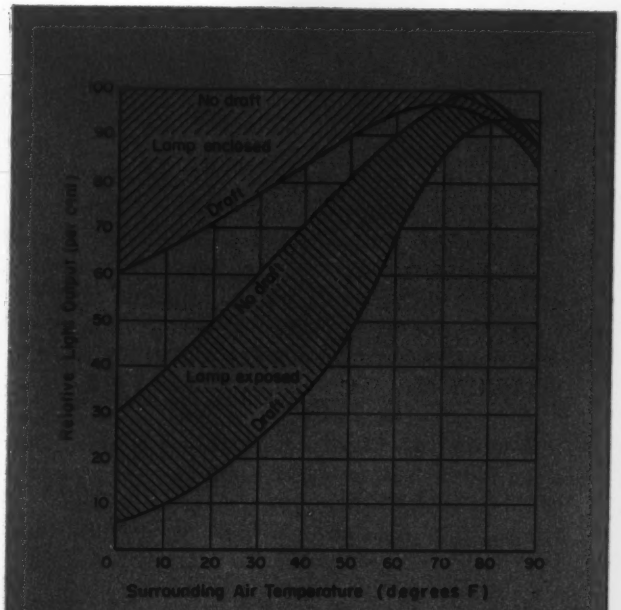


Fig. 14—Above — Effect of surrounding air temperature and air circulation on light output of fluorescent lamps

CONTROL OF LIGHT

After the light source is selected, the primary design problem is the control of light. Few lamps have the desired characteristics of brightness, color, shape, candlepower distribution, etc., suited for direct application without control or modification. Exceptions, in some respects, to this statement might include neon glow lamps, reflector and projector lamps, or type 222 lamps, *Fig.* 15.

To obtain the proper light distribution and color, the designer must work with many types of reflecting and transmitting materials. These are formed into various shapes and contours, which are dependent upon the characteristics of the materials and lighting results expected.

Reflecting Materials: The materials that can be suitably employed as light reflectors range from the shiny or specular types which include mirrored glass or polished aluminum to the diffusing ones such as flat white paint. In between are the spread types like brushed aluminum and the diffuse-specular materials. Porcelain enamel is commonly used in industrial fixtures and is primarily a diffuse coating, but a specular component results from the shiny surface glaze.

Many industrial fluorescent luminaires such as shown in *Fig.* 16 are usually supplied in three finishes—Alzak aluminum, white porcelain enamel, and white baked enamel. The Alzak aluminum finish provides a lower brightness inside the luminaire with a slight sacrifice of luminaire efficiency

Fig. 15—Miniature TL lamps project concentrated light beam at soldering gun tip by means of condensing lenses on bulb ends. Two bulbs designed into unit to provide adequate illumination and prevent shadowing of work

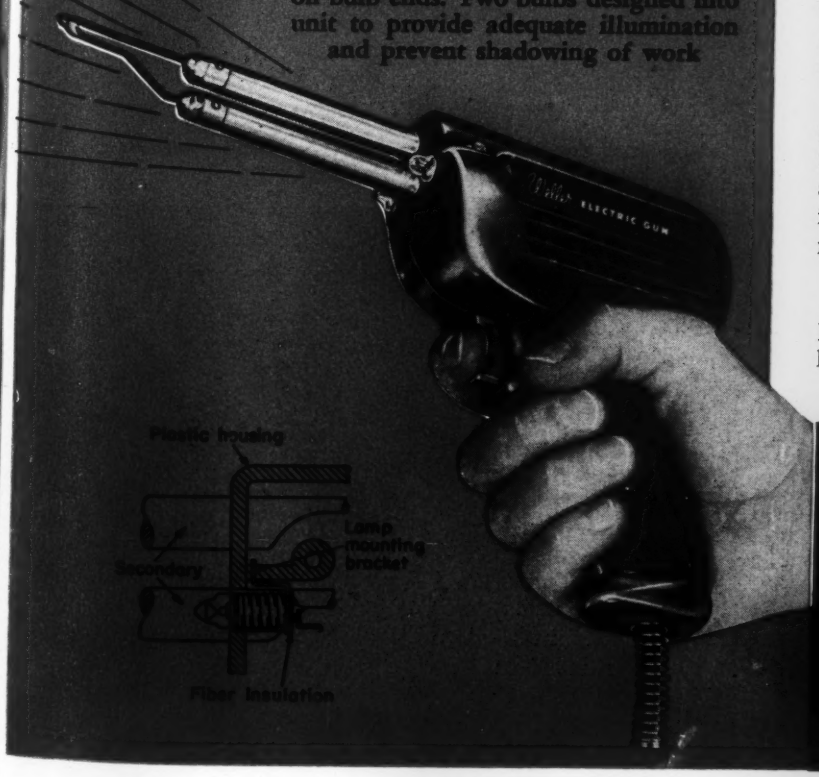
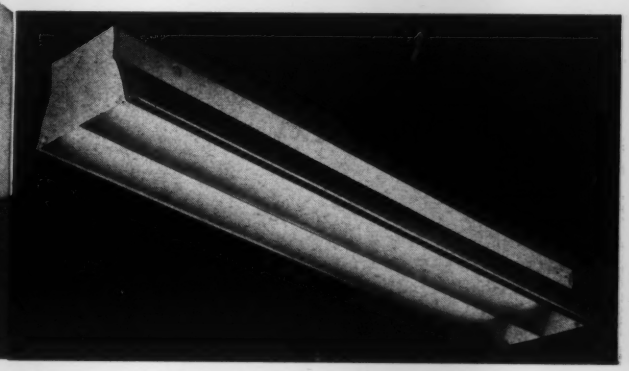


Fig. 16—Typical built-in type industrial fluorescent luminaire can be mounted with rivets, screws or bolts at ends, sides or top



—reflection factor is 70 to 80 per cent. White porcelain enamel is quite durable and easy to clean and has a reflection factor near 80 per cent or higher. Most of the white baked enamel finishes have reflection factors between 80 and 85 per cent and higher.

Reflector Contours: Light rays are most accurately controlled when redirected from shiny or specular surfaces. If these are given certain geometric shapes or contours, definite light patterns or distributions are obtained. The simplest reflector is a plane which obtains a wide variety of control from the type of surface—mirrored to diffuse. Semicircular contours are commonly employed with picture projection lamps, *Fig.* 7, to redirect the light back toward the collecting lenses and thus increase the efficiency of the optical system. Modifications of circular shapes toward parabolic contours, such as done with fluorescent fixture in *Fig.* 16, are common design techniques. Parabolic contours can redirect light from point or line sources into essentially parallel rays. Combinations of circular, parabolic, and plane sections can be employed to produce a wide variety of distributions.

Transmitting Materials: Most clear flat materials such as glass or plastic transmit light with little directional change. Although these materials do little in the way of controlling light, they serve the valuable purpose in machine design of protecting light sources and reflectors from dust, dirt, flying chips, water, oil, corrosive solutions, and gases. Etched, frosted, enameled, and opalescent materials are employed to diffuse, scatter, or spread light.

Light polarizing materials are used to some extent for dimming purposes in pilot lights and have been proposed to practically eliminate the glare problem in vehicle headlighting. Many Boston transit cars have been using polarized headlights quite successfully for some time.

When clear transmitting materials are given special shapes in the form of lenses and prisms, they turn or change the path of light, *Fig.* 17. Automobile headlights have many prisms cast into the lens of the lamp to produce carefully defined light patterns.

DESIGNING FOR ILLUMINATION

Selection of a lamp and methods of controlling its light output is dependent on many environmental and physical construction details and limitations which must be carefully considered. If the need for lighting exists in a machine, then the function of the light becomes the major factor controlling the design planning for this lighting. Since the lighting techniques and equipment employed in lighting for illumination and visual indication are quite different in many respects, they will be treated separately. The following considerations are important when designing built-in lighting for illumination.

Amount of Light: Light source and luminaire selection is primarily dependent upon the number of footcandles required for a particular visual task. Visibility is a function of several basic characteristics of the object or detail being seen and its background. These include size, shape, reflectance or transmittance, time, color, and brightness.

In machining a part, assembling a product, or

Table 1—Recommended Illumination Levels for Machines

Type of Work	Illumination* (ft-c)
Rough	20
Medium	50
Fine	100
Extra fine	300

* These are footcandles maintained in service. Initial values should be 25 to 100 per cent higher to compensate for lamp and luminaire depreciation.

Fig. 17—Tempered prismatic glass lenses in many sizes and shapes provide accurate light control and resist heat and mechanical breakage

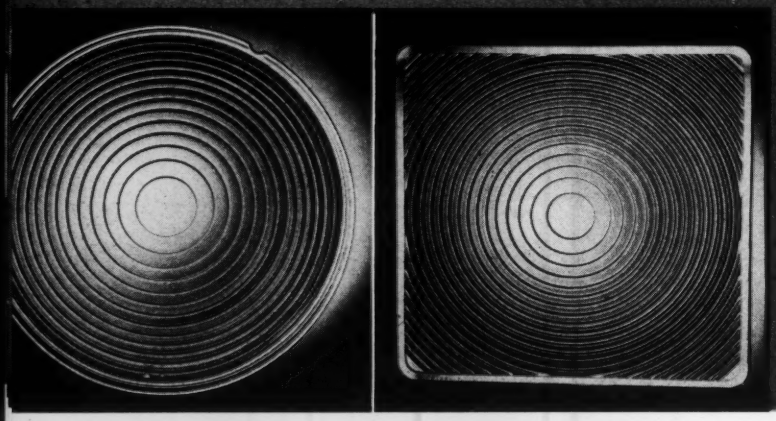
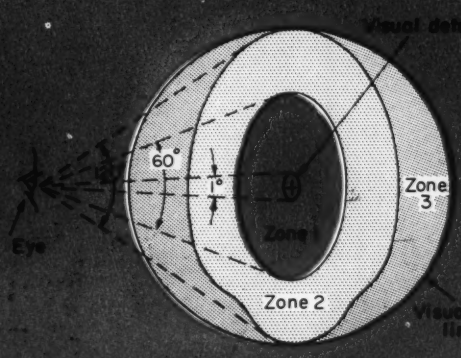


Fig. 18—Field of view of machine operator showing major seeing zones. Brightnesses in zone 1 should not be more than *three* times those in zone 2 or *ten* times those in zone 3



operating a data computer, for example, the size and shape of centering marks on the part, components put into the product, or numbers fed to the computer are rather definitely determined and fixed in size and shape. Reflectances or transmittances of vital details and their backgrounds along with their colors seldom can be changed, except in a few cases, to improve seeing. The eye operates quickly, thus increasing time for seeing does little to increase visibility after a few seconds or in most cases a fraction of a second. Therefore, the designer usually has little influence over the first five characteristics, but he can control the factor of seeing-task brightness. By adding footcandles, brightness differences[1] between objects and their backgrounds are increased with resultant improvements in visibility. Illumination required for machine lighting[2] applications are listed in TABLE 1.

Quality of Light: Brightness and color of the light source and the area surrounding visual tasks controls quality of illumination. There are several factors the designer must consider for this aspect.

BRIGHTNESS RATIOS: Limitations on the ratio of brightnesses in the various parts of the visual field must be made to help insure seeing comfort. For seeing areas in field of view as depicted in *Fig.* 18, the following limitations are given:

1. Brightness of critical seeing area (zone 1) which extends out to a visual angle of about 60 degrees should not be more than *three* times brightness of immediate surround (zone 2), which extends out to about 120 degrees.
2. Brightness of critical seeing area should not be more than *ten* times brightness of area outside immediate surround (zone 3).

Such brightness ratios are to be considered as maximums and reductions are generally beneficial. It should be apparent to the machine designer that these brightness limitations can be met only by employing light finishes on machines, control panels, etc.

GLARE: Excessive brightness in the direction of the eye, generally termed glare, must be prevented or compensated for by increasing adaptation brightness and/or glare-source surround brightness. Glare can be caused by reflected or direct light and must be guarded against in either event. Shiny parts and surfaces must be kept to minimum in the critical seeing area of a machine. The light source itself must be shielded or louvered, *Fig.* 19, to keep uncomfortable brightnesses out of the eye as much as possible.

SHADOWS: Prevention of shadows with built-in lighting is desirable except where silhouettes of details are desired. Silhouette lighting is restricted mostly to visual indication. Elimination of shadows is one important reason for building light into many machines, especially in machine tools, *Fig.* 20.

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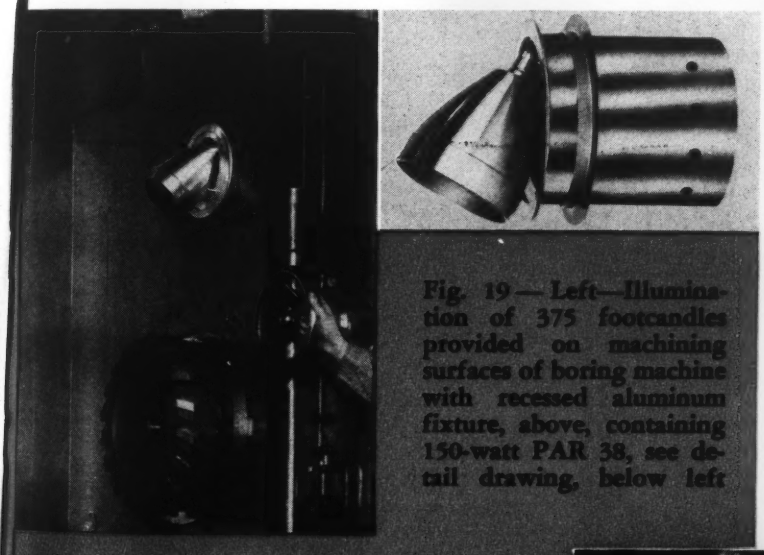
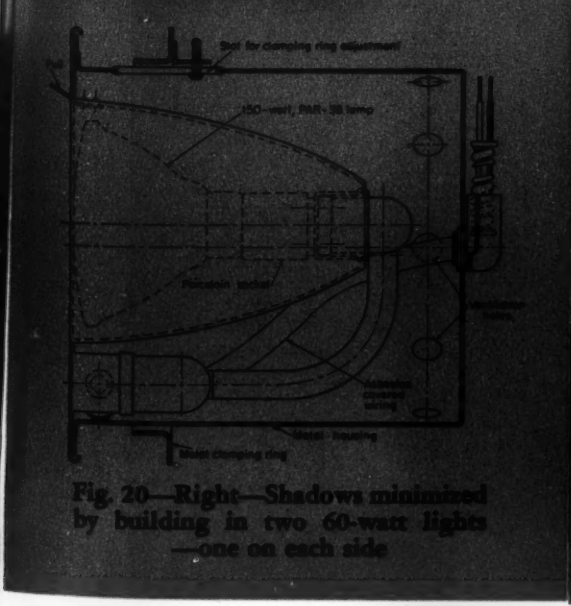


Fig. 19 — Left—Illumination of 375 footcandles provided on machining surfaces of boring machine with recessed aluminum fixture, above, containing 150-watt PAR 38, see detail drawing, below left



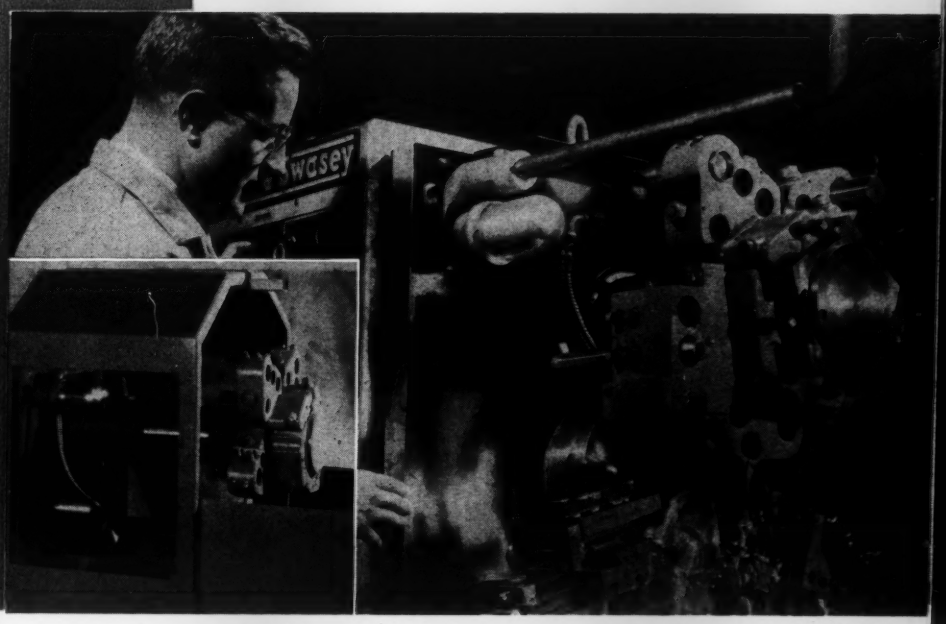


Fig. 20—Right—Shadows minimized by building in two 60-watt lights —one on each side

Shadows become a major factor in the design of control panels, instrument panels, and laboratory equipment, *Fig.* 21.

COLOR OF LIGHT: Tests have shown that different color qualities with equal intensity lighting have little effect on visibility. For most machine lighting which is built-in for purposes of illumination, color of light is not of great consequence. It is important if colored parts, materials, or products must be visually matched, combined, graded, or inspected in a machine on the basis of their color characteristics. Lamp manufacturers will recommend lamps and colors for these highly specialized applications. In general, it is best to use the so-called white sources. For ordinary machine lighting applications, colored sources produce no magical increase in comfort or decrease in physical fatigue as is sometimes claimed.

FINISHES: Reflectances of the finish on most machines, instruments, test equipment, instrument panels, control panels, etc., should range between 20 and 50 per cent. In areas where most of the visual work is done, reflectance values should be at least this high to decrease brightness ratios. The other big advantage of a high-reflectance finish is that it permits most efficient use of the available light from both general lighting and built-in lights. Control panels with dark finishes, *Fig.* 22a, are greatly improved in appearance and seeing comfort by light surfaces, *Fig.* 22b.

Color of finishes is a complete story within itself, but commonly accepted colors on machines today are light buffs, greens and blues. Many instruments, data processing machines, office machines, machine tools, etc., are finished with 15 to 50 per cent reflectance grays.

Environmental Conditions: Almost limitless in number and variety, environmental conditions are of considerable importance in the design of lamps and fixtures into many machines. The following

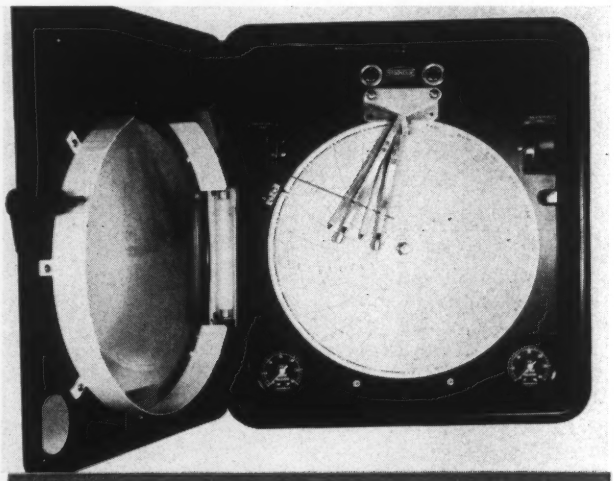


Fig. 21—Above—Besides eliminating shadow on chart caused by case cover of recorder, built-in 4-watt fluorescent light increases chart brightness to permit more accurate readings both near and far

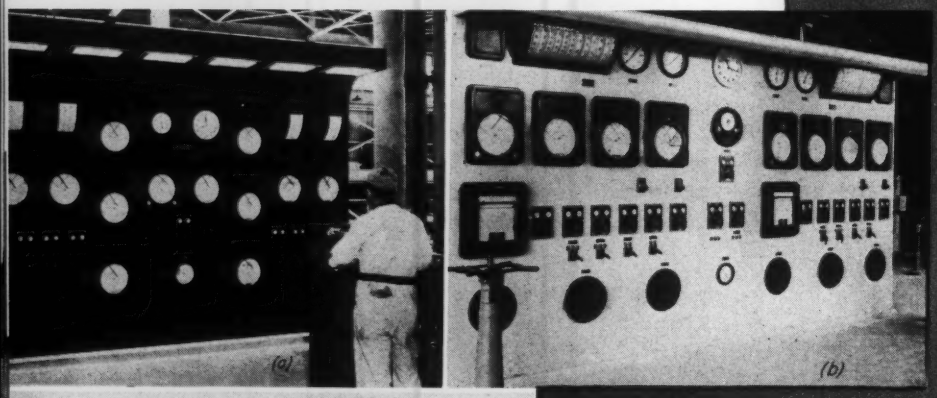


Fig. 22—Left—Dark surfaces on industrial control panel, *a*, are not as conducive to seeing comfort and efficient use of illumination as light-finish panel, *b*. Brightness ratio limitations are met in *b*

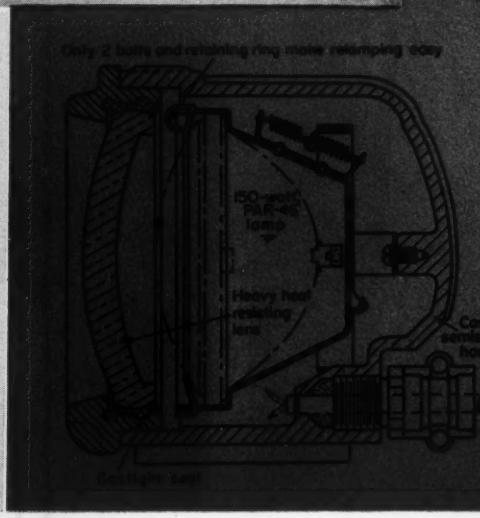


Fig. 23 — Left — Rugged design of explosionproof, mine machine headlight meets Bureau of Mines approval. Spring-mounted lamp holder permits unit to withstand impact. Gastight seal keeps out explosive vapors and dust

are some of the more important ones:

1. Temperature
2. Air circulation
3. Humidity
4. Dust and dirt
5. Flying liquids
6. Flying debris and impact
7. Corrosion
8. Vibration
9. Shock
10. Hazardous locations

Transportation vehicles encounter practically every one of these conditions during their life in hot and cold temperatures, flying stones, salt, etc.

TEMPERATURE: In dealing with this aspect the temperature of surrounding liquids and gases, lamps and the machine itself plays an important role. For low temperature and high-temperature conditions, built-in fluorescent lighting should be discouraged in most cases unless enclosed, as can be seen from the curves in *Fig.* 14. These applications include freezers, refrigerators, stoves, etc.

AIR CIRCULATION: Here too fluorescent lamps are less efficient in heavy drafts. This can be easily handled in the original design by specifying enclosed luminaires with glass or plastic bottoms for protection from the cooling effect of high-velocity air streams. Filament and mercury-vapor lamps are not so limited as far as temperature or air circulation is concerned. Such lamps should not be allowed to become too hot, not only from the standpoint of lamp life but also damage possibilities to surrounding equipment and materials.

HUMIDITY: Few problems exist with any of the light sources in this aspect. It would be desirable to enclose lamps completely in high-humidity areas, but this is usually not necessary. Most filament lamps built into freezers and refrigerators are installed in rubber sockets which seal the moisture out of the socket when the lamp is screwed in tight.

DUST AND DIRT: Reflector and PAR lamps are naturals for dusty and dirty areas because it is simple to clean their smooth glass surfaces. Here too glass and plastic bottoms on fixtures for any

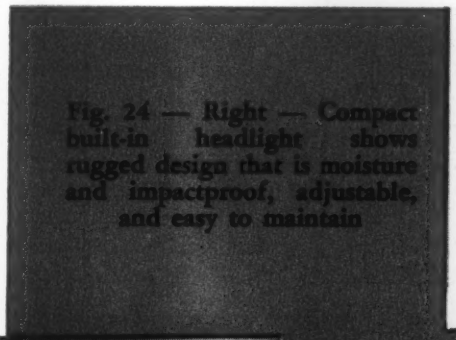
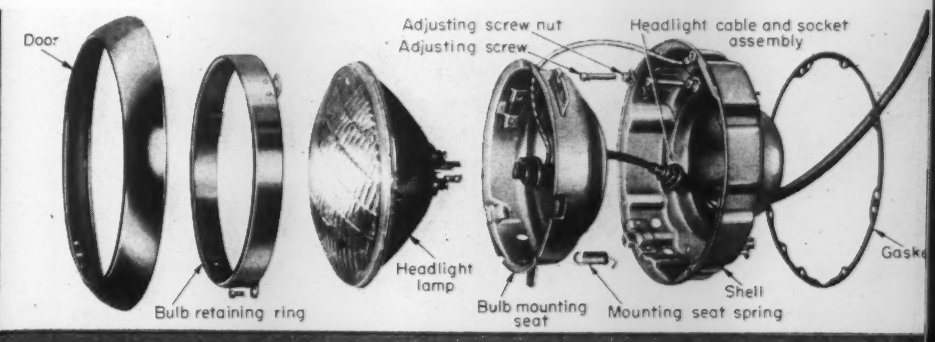


Fig. 24 — Right — Compact built-in headlight shows rugged design that is moisture and impactproof, adjustable, and easy to maintain



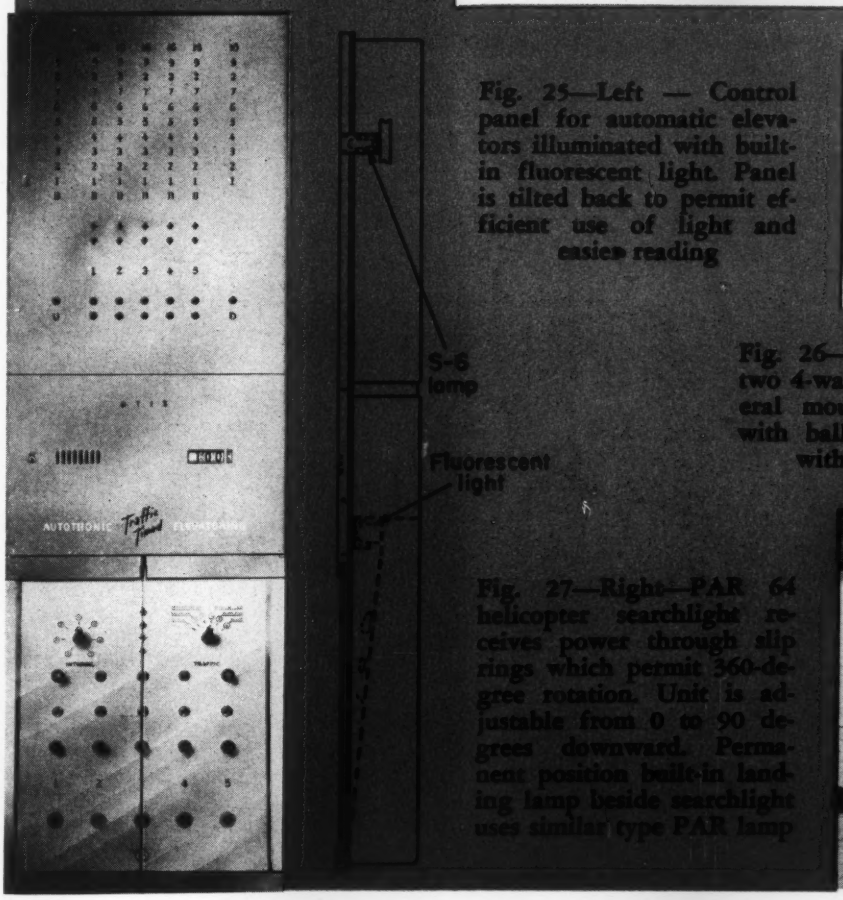


Fig. 25—Left — Control panel for automatic elevators illuminated with built-in fluorescent light. Panel is tilted back to permit efficient use of light and easier reading

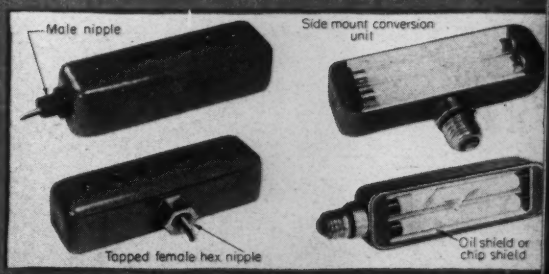


Fig. 26—Above—Small fixtures with two 4-watt fluorescent lamps have several mountings. Units are complete with ballasts and are made with or without oil and chip shields

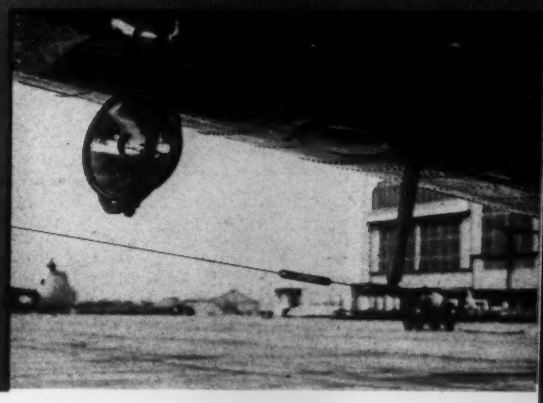


Fig. 27—Right—PAR 64 helicopter searchlight receives power through slip rings which permit 360-degree rotation. Unit is adjustable from 0 to 90 degrees downward. Permanent position built-in landing lamp beside searchlight uses similar type PAR lamp

of the lamp types make it possible to maintain high light output in dirty environments because of cleaning simplicity.

FLYING DEBRIS AND IMPACT: This category includes light bulb breakage by such items as flying metal fragments in machine tools, flying stones in transportation vehicles, dry and liquid abrasive materials in finishing applications, and accidental impact from tools or other hard objects. It is usually necessary to specify hard-glass lamps or use fixtures or globes made of plastic or hard glass, *Figs.* 2, 3, and 20. Metal shields or guards are used to protect lamps from breakage in many machines. Screening or punched metal, *Fig.* 1, are commonly employed in such applications.

FLYING LIQUIDS: Temperatures of flying liquids are usually much cooler than any of the light sources, especially the filament and mercury-vapor types, and may break bulbs of lamps from thermal shock. Therefore, it is best to protect most lamps by using enclosed luminaires having plastic or hard-glass covers made waterproof with gaskets. Hard-glass flood and spotlights can be mounted in high-necked sockets. These lamp holders can be made waterproof to prevent electric shorts by gaskets.

CORROSION: Liquids and gases that are corrosive must be guarded against by specifying either well sealed lamp sockets or completely sealed fixtures. Here of course the type of sealer must be able to withstand the corrosion characteristics of liquid or gas especially the acidic or alkaline varieties.

VIBRATION AND SHOCK: Here the concern is light failure from lamp filament breakage. As pointed out previously fluorescent lamps or shock and vibration type incandescent lamps have sturdy filament designs and should be used in those areas where general service lamps will not hold up. If heat and power consumption are of importance, use of fluorescent lamps should be considered. Shock and vibration can be damped by such techniques as mounting lamps or fixtures on springs, *Fig.* 23, and in or on rubber or plastic, *Fig.* 3.

HAZARDOUS LOCATIONS: As defined by the National Electric Code, hazardous locations are areas in which explosions and/or fires may occur because of the presence of (1) explosive gases or vapors, (2) combustible dusts in the atmosphere, or (3) locations in which "flash fires" may occur because of accumulations of readily ignitable fibres or flyings.

For Class 1 locations, lamps are encased in heavy metal and glass luminaires. These are designed to prevent hot gases caused by possible internal explosions from reaching surrounding atmosphere at sufficiently high temperatures to create external explosions. These internal explosions may be caused by electric arcs in wiring and switching circuits or hot filaments in case of light bulb breakage.

In Classes 2 and 3, luminaire shape reduces accumulation of combustible materials. Also, luminaires are usually larger than those employed in Class 1 to provide sufficient radiating surface to prevent high concentrations of heat from the lamp. Only code-approved complete luminaires should be employed in machines used in areas under any of these classifications.

The design of an explosionproof mine machine headlight is shown in *Fig.* 23. This basic type of sturdy design is employed in lesser degree for all types of heavy mobile machinery.

Lamp and Fixture Mounting: A wide variety of standard sockets are available for practically every

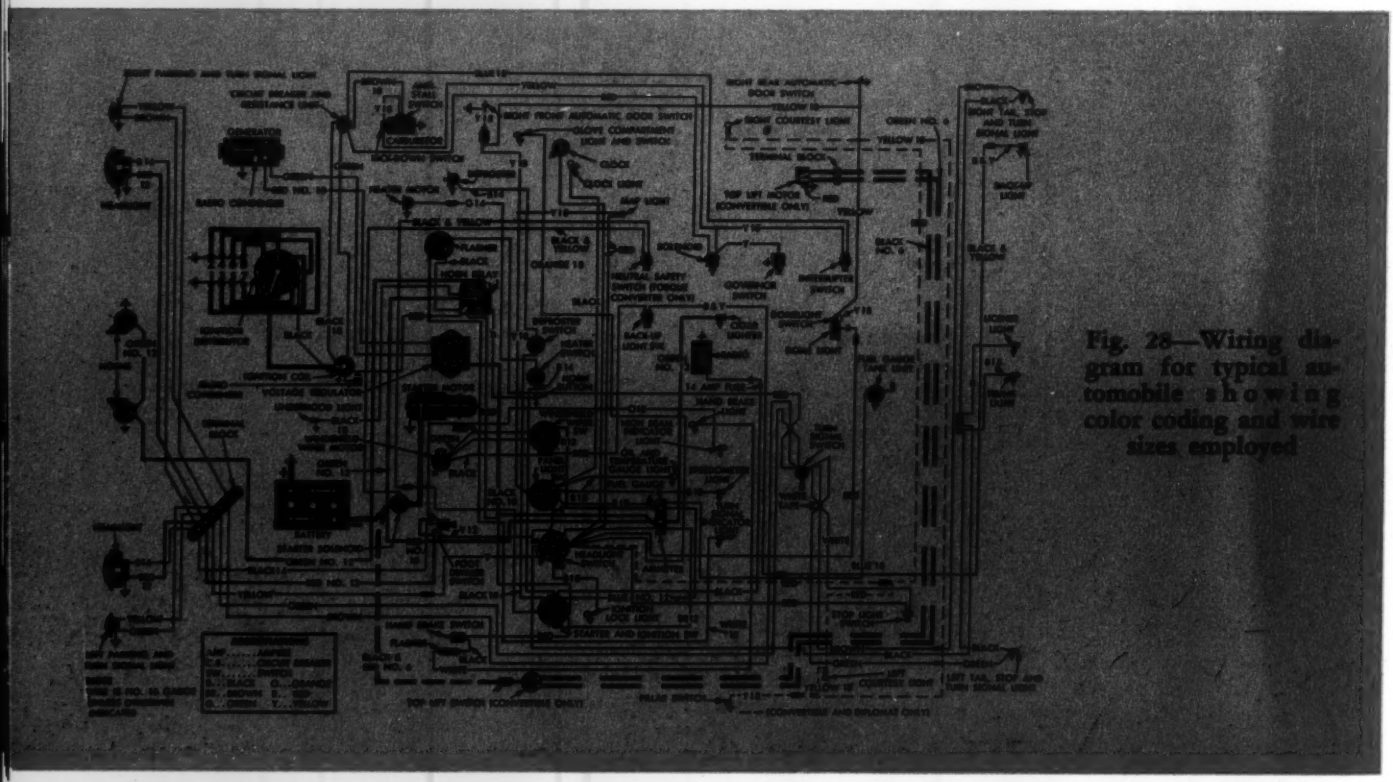


Fig. 28—Wiring diagram for typical automobile showing color coding and wire sizes employed

type of lamp manufactured. For some of the built-in lighting applications employing PAR lamps, however, bulb mounting seats must be designed for rigid positioning of lamps. Screw-mounted metal clips or retaining rings must be employed to hold bulbs in place as shown in *Figs.* 5 and 24. Most sockets are attached or held in place by means of screws, bolts, or rivets, but in some cases these can be supported with springs, mounted in plastic, rubber, or other special service materials.

Fluorescent lamps require either push-pull or twist-in sockets which are mounted with machine screws. Techniques used in two applications of fluorescent lamps are shown in *Figs.* 21 and 25.

Incandescent or fluorescent lighting fixtures can be made quite simple to mount, *Figs.* 19 and 26.

Wiring: Voltage and current requirements of lamps designed into a machine along with the en-

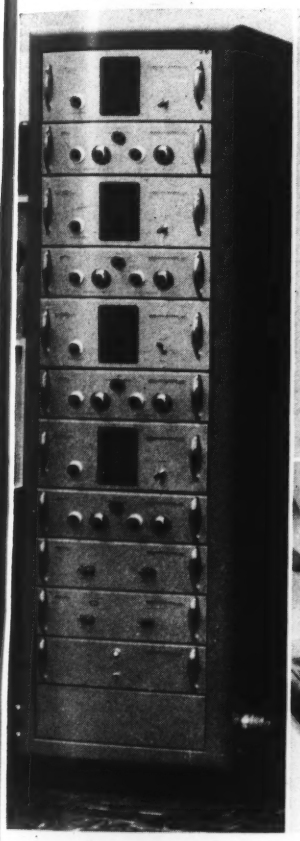
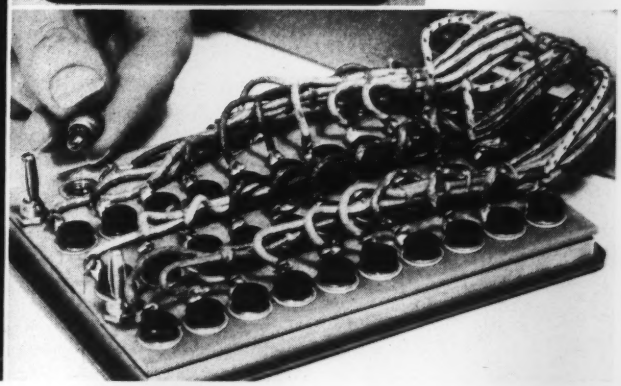


Fig. 29 — Left — "Grain-of-wheat" incandescent lamps mounted in threaded bases brightly transilluminate numbers on indicator panel of data converter. Lamp panel mounted on banana-plug jacks permit ease of maintenance

Fig. 30—Below—Typical enclosed and open type indicator light assemblies for miniature incandescent and neon lamps



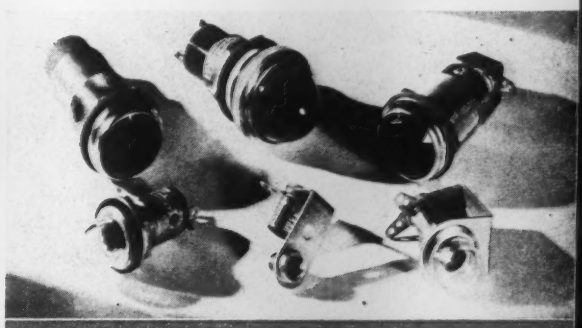


Fig. 31—Left — Light from miniature lamps are conducted through Plexiglass rods to produce two circular spots of light through translucent dial of interpolation oscillator. Design provides simplified socket mounting, accurate light control, and easy removal of center unit for servicing

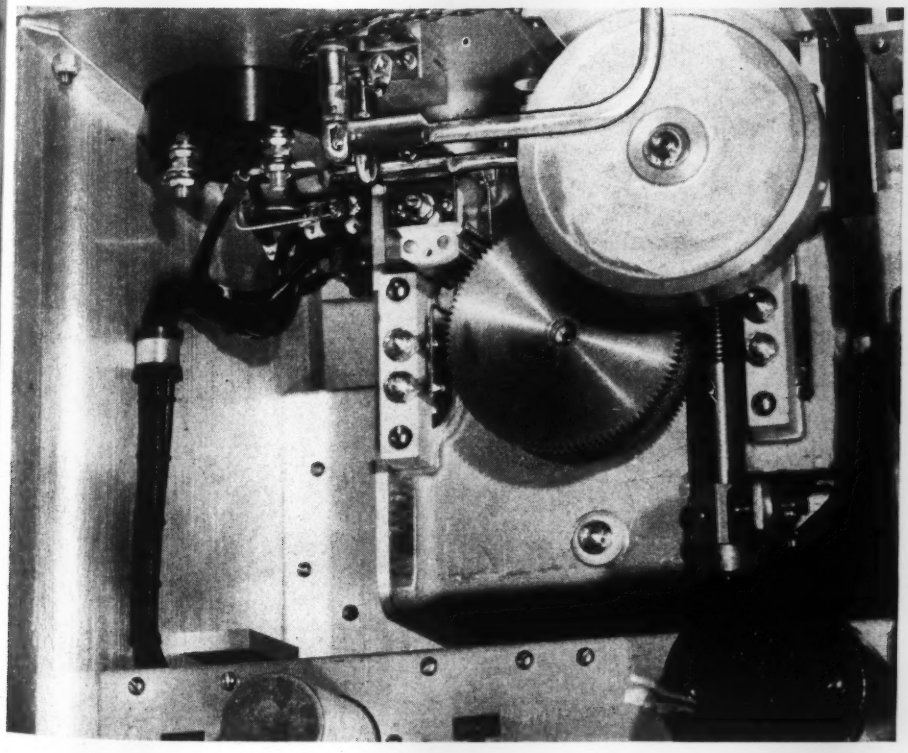
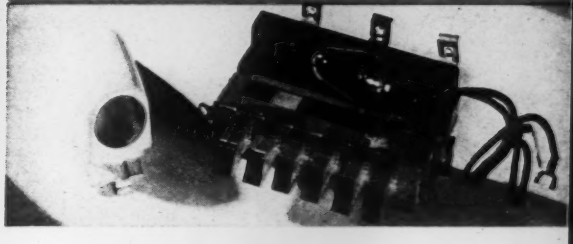


Fig. 32 — Below — Clear plastic pushbuttons for electric range are transilluminated in five colors by means of different color filters placed between each button and 7-watt lamp. Size of light slits under color filters, filter transmission, reflector contour, and lamp position make buttons appear equal in brightness



vironmental and service conditions determine wire size and insulation. Where many wires are necessary, a wire coding technique is a must for easy, fast, and accurate assembly on the production line and to permit ease in maintenance. Common coding methods used include numbered tabs or colored wire, *Fig.* 28. Wiring and insulation should be protected from overloading with fuses; adequate ventilation should be provided for the wiring.

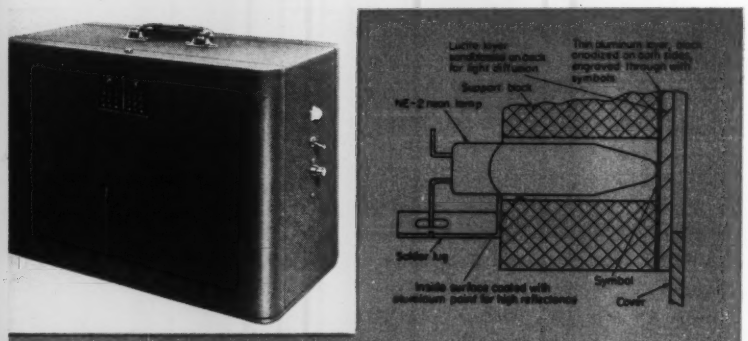


Fig. 33—Above—Miniature neon lamp mounting technique in data converter. Lamps are soldered in permanently but designed for easy accessibility

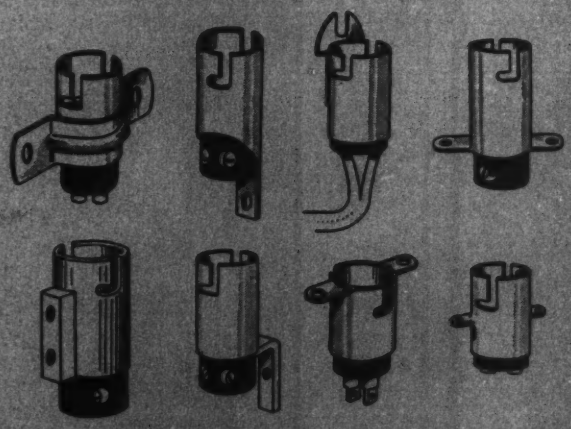
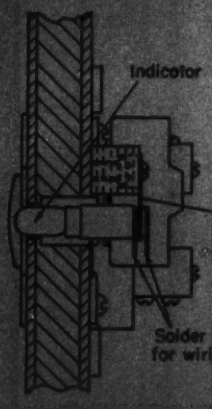


Fig. 34—Above—Typical indicator light mounting methods for screw or bolt fastening

Fig. 35 — Design of screw - mounted bracket-type indicator light in register of electronic data processing machine

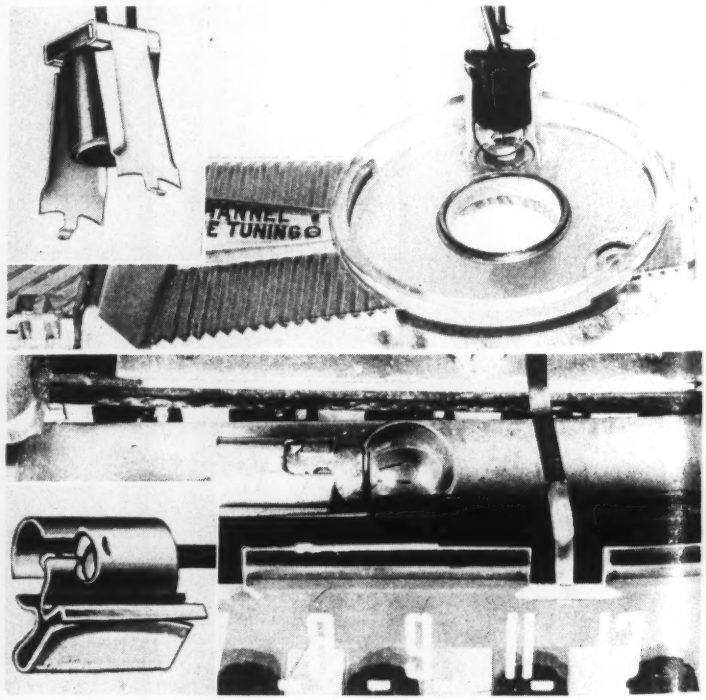


Maintenance: Light output reduction is caused by lamps producing less light as they get older and by luminaire and machine light-reflecting surfaces becoming defaced or dirty. The designer cannot do much about this depreciation but he can specify lamps, luminaires and machine finishes that are durable, stain resistant, and easy to keep clean. Openings above lamps that permit good air flow upward reduce dirt accumulation on reflecting surfaces of the fixture and on the lamp itself.

Appearance: In airplanes, appliances, trains, automobiles, office machines, ships, etc., appearance plays a key role in lighting design. While important, it should be given a secondary position in industrial machine lighting to minimize design and production costs.

Cost: More than the initial expense of fixtures and lamps are included in the cost of light. The machine owner pays annual operating costs which include electric power charges plus maintenance expenses, lamp replacement and lamp and luminaire cleaning. Therefore, costwise, a choice must be made among incandescent, fluorescent, and mercury-vapor lighting. Incandescent has a low initial cost and low maintenance cost while fluorescent and mercury vapor are more efficient. Heat and quality of lighting may indicate fluorescent even if it is more expensive. On most machines high-quality lighting can be specified in the original design for a small percentage of the final selling price. Cost of lighting is usually insignificant in transportation equipment, commercial and industrial machines,

Fig. 36—Snap-in dial light mounted behind television channel indicator, top, and slide-on dial light located behind radio dial, bottom



and home appliances, but in a majority of cases safe and efficient operation is dependent to a large degree upon the operator being able to see well.

DESIGNING FOR INDICATION

Many of the methods and techniques employed in designing well-illuminated work surfaces in and around machines may be used in designing illuminated instrument and control panels. The same basic light control knowledge is used in bouncing light off the reflector in a rotating navigation light on the tail of an airplane, *Fig.* 5, as is employed to reflect light from the work surface of an electric range. However, some fundamental design differences do appear in transilluminating surfaces, jewels, and reflectors in signal and pilot lights. Lamp and fixture mounting methods often differ, too.

Lamp Selection: A broad range of lamp sizes is employed for visual signaling and indication. For example, little "grain-of-wheat" lamps serve to transilluminate numbers in a data computer, *Fig.* 29, while a brilliant PAR 36 lights the navigation assembly, *Fig.* 5. Advantages of incandescent lamps used for visual indication are that they are bright and adjustable in brightness and are available in many sizes and voltages; disadvantages are relatively fragile filaments and short life. On the other hand, neon lamps are rugged, reliable, require little power, and have long life, but are only available in limited sizes, brightnesses, or colors. Also, neon lamps require 65 volts ac or 90 volts dc to glow.

Lights that are built into machines for purposes of signaling, warning, numerical indication, etc., rely on a variety of light control media. For example, refractive devices are extensively incorporated in automobile taillights, turn-signal lights, license-plate lights, etc. Of course, pilot or dial light assemblies of all types, *Fig.* 30, contain a wide variety of light reflecting and refracting jewels and covers. Bending of light around corners using internal light reflections in glass or plastic rods, *Fig.* 31, is finding many applications in built-in visual indication lighting where space and mounting limitations are severe.

The designer can easily select the type and size of indicator light assembly by determining the space, color, brightness, mounting, reliability, and maintenance requirements. There are few hard and fast rules on color selection—in many instances selection depends upon the complexity and use of the machine.

Brightness necessary in indicator lights depends on the ambient lighting conditions in which a particular machine is normally operated, observation distance, size of the light, and purpose of the light. Obviously a failure or danger warning-light generally should be brighter than would even be considered comfortable in order to attract sufficient attention. Colored filters used in indicator light assemblies, etc., have different transmittances for different colors and eye response varies for different colors; this must be taken into consideration. For example, plastic pushbuttons in the multiple-circuit switch, *Fig.* 32, were made to appear about equal in brightness for five widely different colors by careful design of reflector, lamp position, and color filters. Adjustable brightness lamps in instrument panels are necessary in most applications.

Mounting of Indicator Lights: Popularity and versatility of pilot lights and dial lights for visual indication purposes stems largely from the many lamp and fixture mounting techniques available to the designer. The simplest mounting technique is to solder-in the lamp permanently, *Figs.* 12 and 33, but this is not recommended, except for some neon lamps, because of lamp replacement difficulties.

The simplest and most economical pilot or dial light assembly is a plain socket fitted with mounting clamps, brackets or projections that have threaded or unthreaded holes, *Fig.* 34. These allow secure attachment to machine panels and frameworks with wood screws, machine screws, or bolts, *Fig.* 35. Snap-in and slide-on types of units, *Fig.* 36, are widely employed in dial lighting applications because of low initial cost and ease of assembly on production lines. Most types of indicator lights are available with single-lead grounded sockets or twin-lead insulated sockets.

Two other basic mechanical arrangements of signal and indicator light assemblies are the open and enclosed types shown in *Fig.* 30 which include jewel assemblies, sockets, and brackets or fixtures. These mount by clamping the entire unit to a panel through circular holes with nuts or threaded caps from the front. A waterproof and oilproof pilot light is shown in *Fig.* 37.

High reliability and easy maintenance are usually important in indicator light design. A valuable machine may depend on one indicator light always functioning. Thus, it is a good design to build in two lamps for the same indication function, *Fig.* 38. In this case, one lamp is on a flashing circuit while the other is on steady voltage. The operator acknowledges the signal indication by pressing a button. The constant-brightness lamp stays lit until a trouble is fixed or a process control is turned

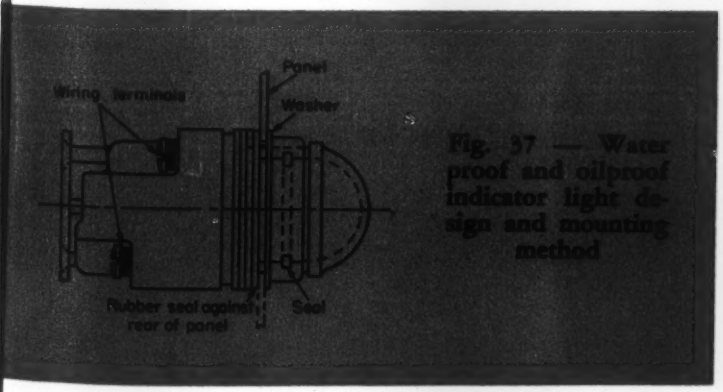
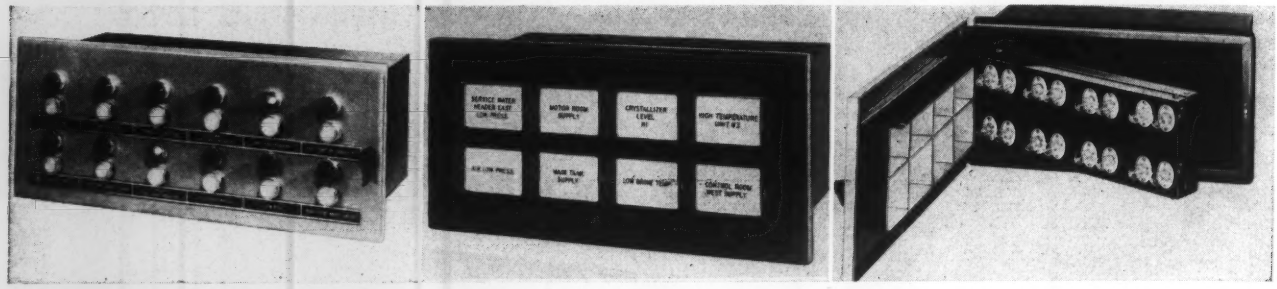


Fig. 37 — Waterproof and oilproof indicator light design and mounting method



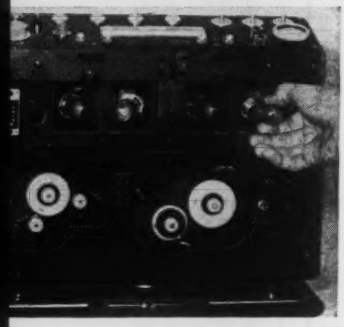


Fig. 38—Above — Hinged indicator-light, cover panels and lamp panels permit easy and fast cleaning, repair, and lamp replacement. Using two lamps for one indication purpose increases reliability

Fig. 39—Costly data recording interruptions prevented by oscillograph design which automatically switches to reserve galvanometer lamp in case of main lamp burnout

off, on, or changed.

When the recording oscillograph, *Fig.* 39, entered its design phase, the factor of operation reliability was given prime consideration. A relay circuit is provided for each of the main galvanometer recording lamps which automatically switches power to a reserve lamp in the event of main lamp failure. Positive indication of recording lamp operation before and during an experiment is assured, because indicator jewels on control panel are transilluminated directly by light conducted through Lucite rods from each recording lamp.

Another major consideration in selecting and designing-in indicator lights is the ease with which they can be maintained. Of course, the biggest maintenance concern is lamp replacement in case of a burnout. Many pilot and dial light assemblies have removable caps to insure ease and speed in lamp replacement. If these are not employed, the design of the machine and the location of the indicator lights should be such that lamps are readily accessible from inside the unit or the indicator lights should be mounted on removable panels, *Fig.* 29, or on hinged panels, *Fig.* 38.

In the final approach to indicator lighting, reliability of operation and simplicity of design must be balanced against ease of maintenance and cost.

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W. H. Brady Co. ..... Milwaukee, Wis.
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G. A. Gray Co. (*Fig.* 19) ..... Cincinnati, O.
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Hetherington Inc. ..... Sharon Hill, Pa.
Hoover Co. ..... North Canton, O.
Industrial Control Panel Co. ..... Chicago, Ill.
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Magic Chef Inc. ..... St. Louis, Mo.
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Mason-Neilan Regulator Co. (*Fig.* 21) ..... Boston, Mass,
Mitchell Mfg. Co. ..... Chicago, Ill.
Frank W. Morse Co. (*Fig.* 34) ..... Boston, Mass.
Nash-Kelvinator Corp. ..... Detroit, Mich.
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Otis Elevator Co. (*Fig.* 25) ..... New York, N. Y.
Pacific Transducer Corp. ..... Los Angeles, Calif.
Panellit Inc. (*Fig.* 38) ..... Chicago, Ill.
Photo Research Corp. ..... Burbank, Calif.
Piasecki Helicopter Corp. (*Fig.* 27) ..... Morton, Pa.
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Prescolite Mfg. Corp. ..... Neshaminy, Pa.
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Swivelier Co. Inc. (*Fig.* 19) ..... Brooklyn, N. Y.
Sylvania Electric Products Inc. ..... Salem, Mass.
Telechron Inc., Dept. G. E. Co. ..... Ashland, Mass.
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Weller Electric Corp. (*Fig.* 15) ..... Easton, Pa.
Westinghouse Electric Corp. (*Figs.* 14 and 23) ..... Pittsburgh, Pa.
Yarnall-Waring Co. (*Fig.* 10) ..... Philadelphia, Pa.
Zenith Radio Corp. ..... Chicago, Ill.

design properties of materials 3

Influence of Heat Treatment and Cold Working on tensile strength ranges

By Robert L. Stedfeld
Associate Editor, Machine Design

IN APPRAISAL of eligible materials for a machine part, strength in tension is one of the primary factors, since this property is usually used as an index of strength of the material. But careful consideration must be given the variations possible in tensile strength, not only in considering tensile strength figures for evaluation, but also to permit effective appraisal of the strength potentials of any material.

Some of the "chance" variations, and variations occurring as a result of design, have been pointed out in a previous article (Part 2, November, 1953, Page 161). These relatively uncontrolled factors—variations between lots, variations introduced by form and size, and directional characteristics—must be kept in mind.

Equally important, however, are the strength potentials of each class of engineering materials. Conventional methods of raising strength levels by heat treating and cold working have large effects on widening the range of tensile strength of metals. These ranges are shown for a wide group of materials in *Fig.* 2 of the previous article. The present article summarizes the methods for raising strength levels for a number of these materials and points out some of the practical significance of these methods. Almost all metallic materials can be worked to increase strength level; many can be heat-treated. Nonmetallics usually cannot be heat-treated or worked in the conventional sense of the terms, but other factors greatly influence tensile strength.

One consideration will not be discussed—the effects of annealing, normalizing or stress relieving. Although these are major heat-treatment techniques, their primary purposes are either softening and increasing ductility (annealing), or producing a stabilized metallurgical structure. None of the three is carried out primarily for increasing strength level, although normalizing or stress relieving may have a beneficial effect on strength by relieving internal strains.

Wrought Carbon and Alloy Steels: Ranges of strength possible by cold drawing or heat treatment are indicated for a number of typical carbon and alloy steels in *Fig.* 1. Treatment or condition has been noted in each case; values at the left-hand

Fig. 1—Tensile Strength Ranges of Carbon, Alloy and Stainless Steels

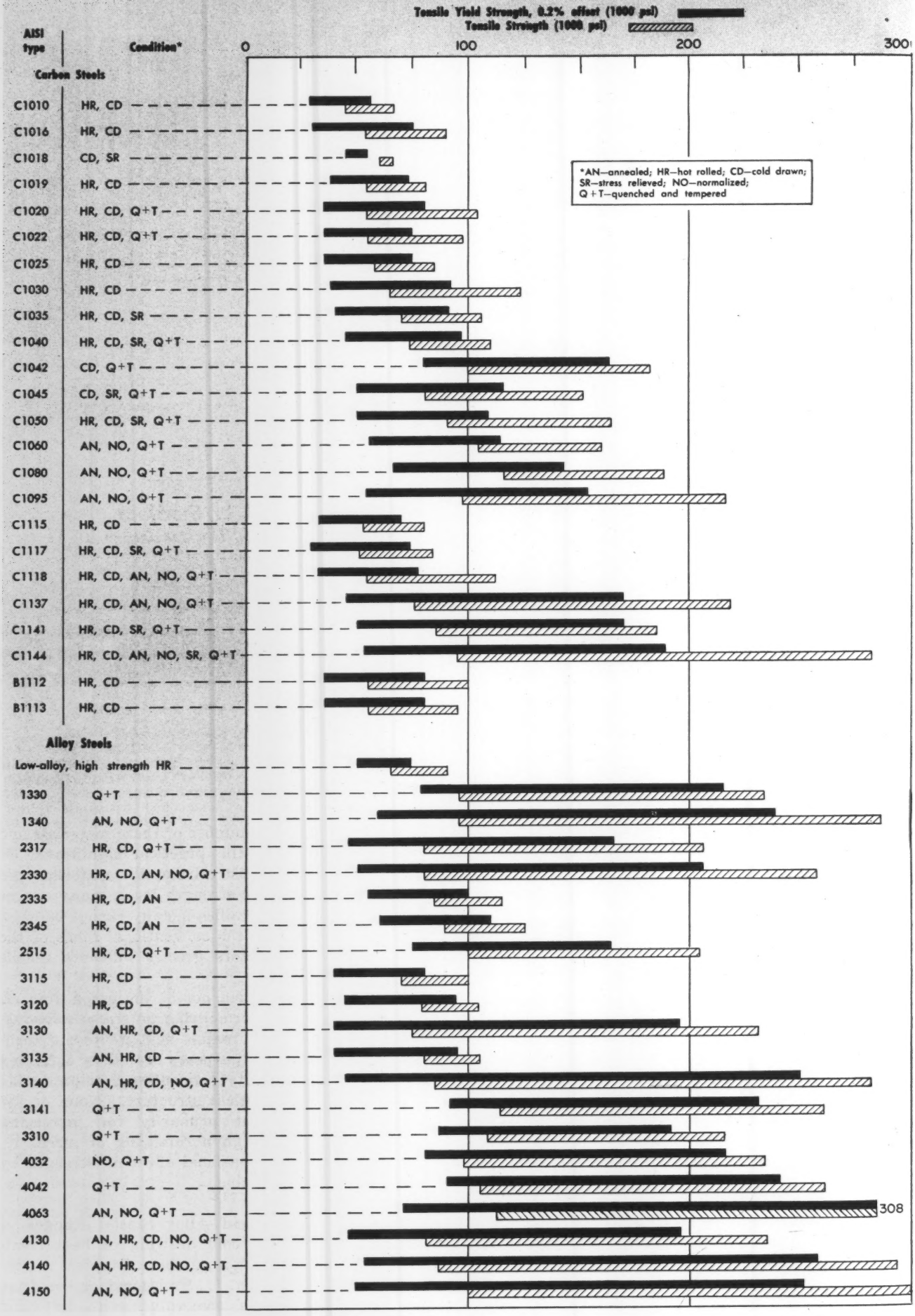
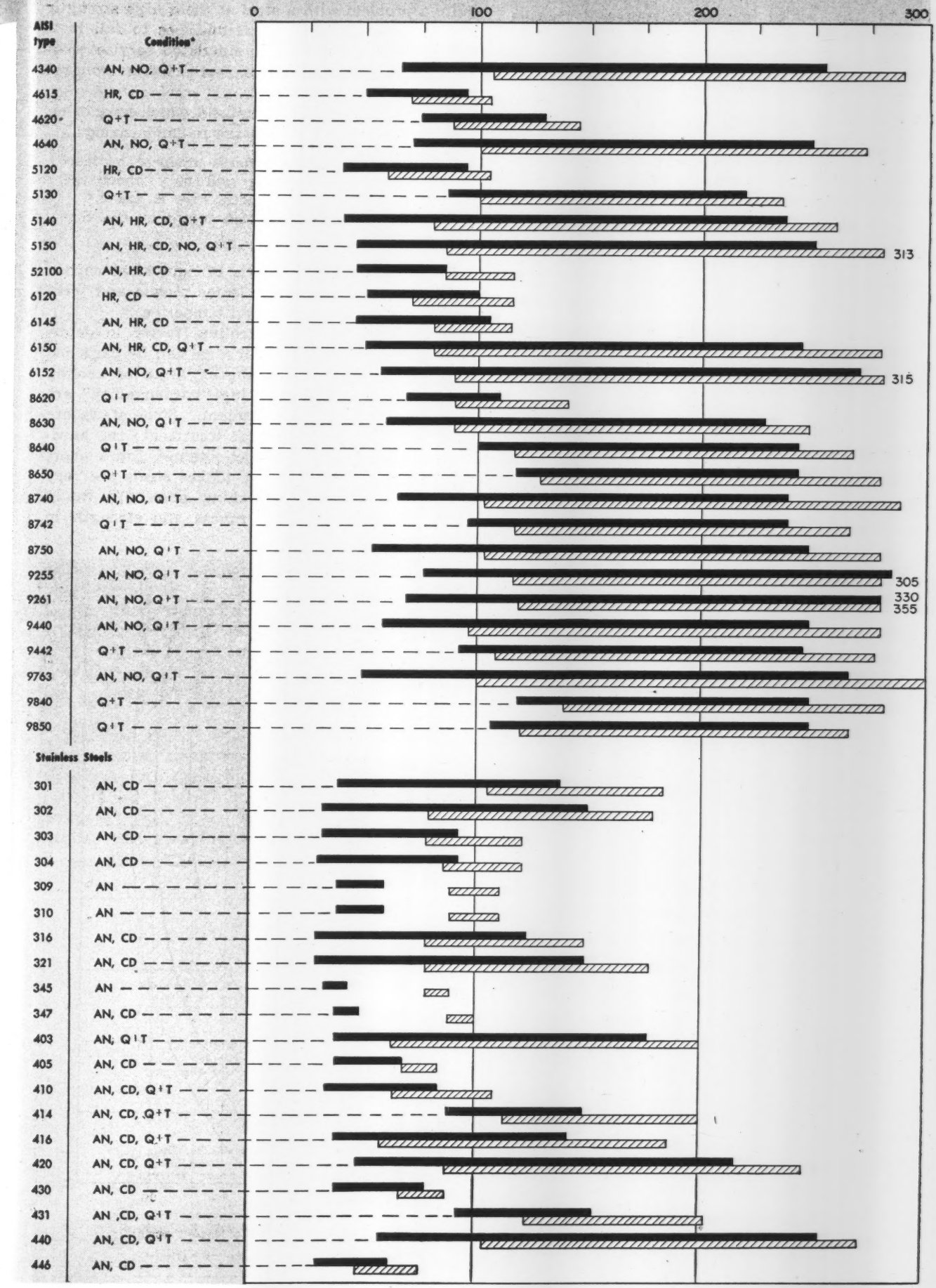


Fig. 1 (cont.) — Carbon, Alloy and Stainless Steels



TENSILE STRENGTH RANGES

end of the scales generally represent tensile strength in the as-rolled, annealed or normalized condition, with higher strength (and corresponding higher hardness and lower ductility) being obtained by cold drawing or heat treatment. Values are typical for ½ through 1-inch rounds.

By and large, steels are not used much above the 200,000-psi tensile strength range, although recently some work has been done in utilizing 4340 steel at a 260,000 to 280,000-psi level—a very high value for this steel. At these high strength levels, strength to weight ratio is equal or superior to the strongest aluminum or titanium alloys.

Very careful design, however, and close control of heat treating and manufacturing processes are necessary.[1] Many deep-hardening steels can be heat treated to strength levels well above this range, but chief problems are notch sensitivity, embrittlement and quench cracking during heat treatment, and hydrogen embrittlement from pickling and plating operations. By careful control of design and processing, these hazards can be minimized, although they must be recognized and allowances made. Impact loading, for instance, which may be resisted successfully by aluminum because of its low modulus of elasticity, may be quite a problem with a steel at these high strength levels, since the steel has tendencies to fail in a brittle manner. Actual or simulated service tests must be conducted where impact or stress concentration may be present.

Several basic facts about steels, which have often been mentioned before, deserve re-emphasizing:

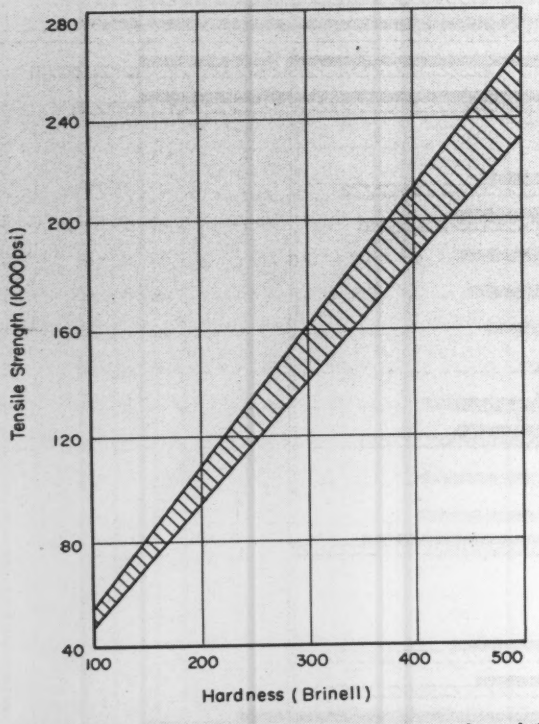
1. Steels of the same hardness produced by tempering after hardening will have about the same tensile yield strength, *Figs.* 2 and 3.[2]
2. Maximum hardness is determined by the carbon content, *Fig.* 4.[3]

Thus in thin sections, steels of equivalent carbon content produce about the same tensile and yield strength after quenching and tempering.

Section size is the controlling factor in determining whether a particular steel can be hardened to the proper tensile strength. Rate of cooling upon quenching and resulting "hardenability" are determined by the alloy content. Some steels are sluggish in response to heat treatment; the hardened structure can only be obtained for a short distance below the surface. Other steels are very sensitive; the same quenching procedure would result in much higher hardness and strength in

[1]References are tabulated at end of article.

Fig. 2—Below—Relationship between tensile strength and hardness for quenched and tempered alloy steels



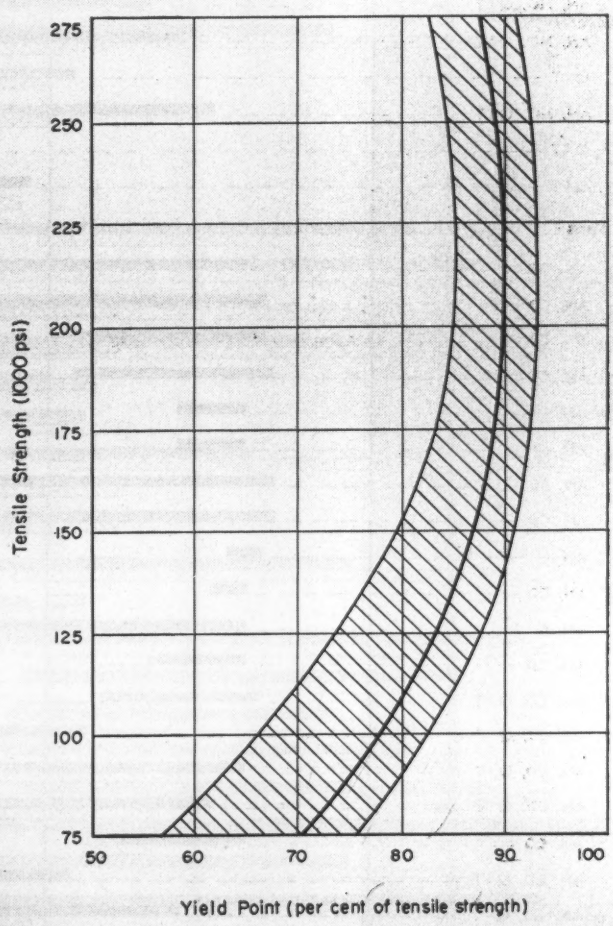


Fig. 3—Right—Normal expectancy for yield point percentage of tensile strength for quenched and tempered alloy steels. Values in the area to left of the average curve usually denote incomplete response to hardening

Fig. 4—Below—Dependence of maximum possible hardness on carbon content for plain carbon or low alloy steels

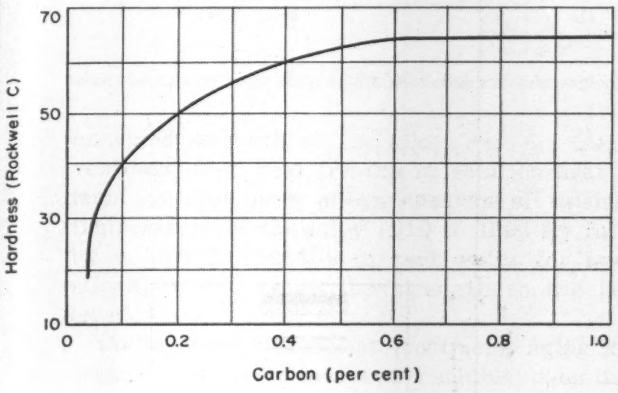
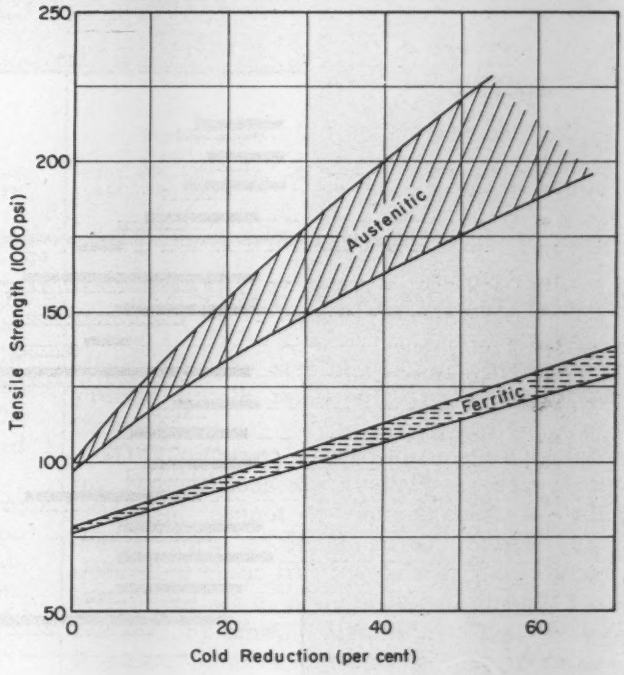


Fig. 5—Right—Effect of cold reduction on strength of stainless steels



equivalent-size specimens. Consequently, these "deep-hardening" steels are usually reserved for larger pieces where a strong, through-hardened structure is needed. Further consideration will be given to hardenability in a later article; TABLE 1, however, summarizes the hardenability characteristics of direct-hardening alloy steels.[2]

Stainless Steels: Stainlesses fall naturally into three groups, TABLE 2.[4] Of these, the martensitic stainlesses are strengthened by usual heat treating procedures. Ferritic stainlesses are not, and are normally used in the annealed state where they exhibit their maximum corrosion resistance and ductility. Austenitic stainlesses, which are nonhardenable by heat treating, are appreciably strengthened by cold work, *Fig.* 5. Representative strength ranges are outlined in *Fig.* 1.

Also available are several special stainlesses which fall generally into the "austenitic" group, but which are precipitation hardening. Resembling the Type 301 to 304 stainlesses in corrosion resistance, they offer equal or higher strengths when hardened.

Wrought Aluminum Alloys: Many of the aluminum alloys can be heat treated, TABLE 3, to provide tensile strengths ranging from 1.8 to 2.7 times the

Table 1—Hardenability of Wrought Alloy Steels

Carbon Content (mean %)	Hardenability		
	Low	Medium	High
0.30-0.37 Small and moderate-sized parts; moderate strength, high toughness	SAE 1330, 1335, 4037, 4042†, 4130, 5130, 5132, 8630	SAE 2330, 3130, 3135, 4137, 5135, 8635, 8637, 8735	
0.40-0.42 Medium and large-size parts requiring high strength and good toughness	SAE 1340, 4047†, 5140	SAE 2340, 3140, 4053, 4063†, 4140, 4640, 8640, 8641, 8642, 8740	SAE 4340, 9840
0.45-0.50 Fairly high hardness and strength, moderate toughness; 90% min martensite as oil-quenched; gears, etc.	SAE 5045, 5046, 5145	SAE 4145, 5147, 5150, 8645, 8650, 8745, 8750	SAE 4150
0.50-0.62 Extra hardness and strength; springs, hand tools, cutting edges, etc.		SAE 4068†, 5150, 5152, 5155, 6150, 8650, 9254, 9255, 9260, 9261	SAE 8653, 8655, 8660, 9262
1.02 High wear resistance and hardness; antifriction bearings	SAE 50100	SAE 51100, 52100	

*Carburizing grades not included. †Carbon-molybdenum steels; higher carbon content usually specified because of low alloy content; grouped on application basis rather than carbon content.

Fig. 6—Wrought Nonferrous Alloy Tensile Strength Ranges

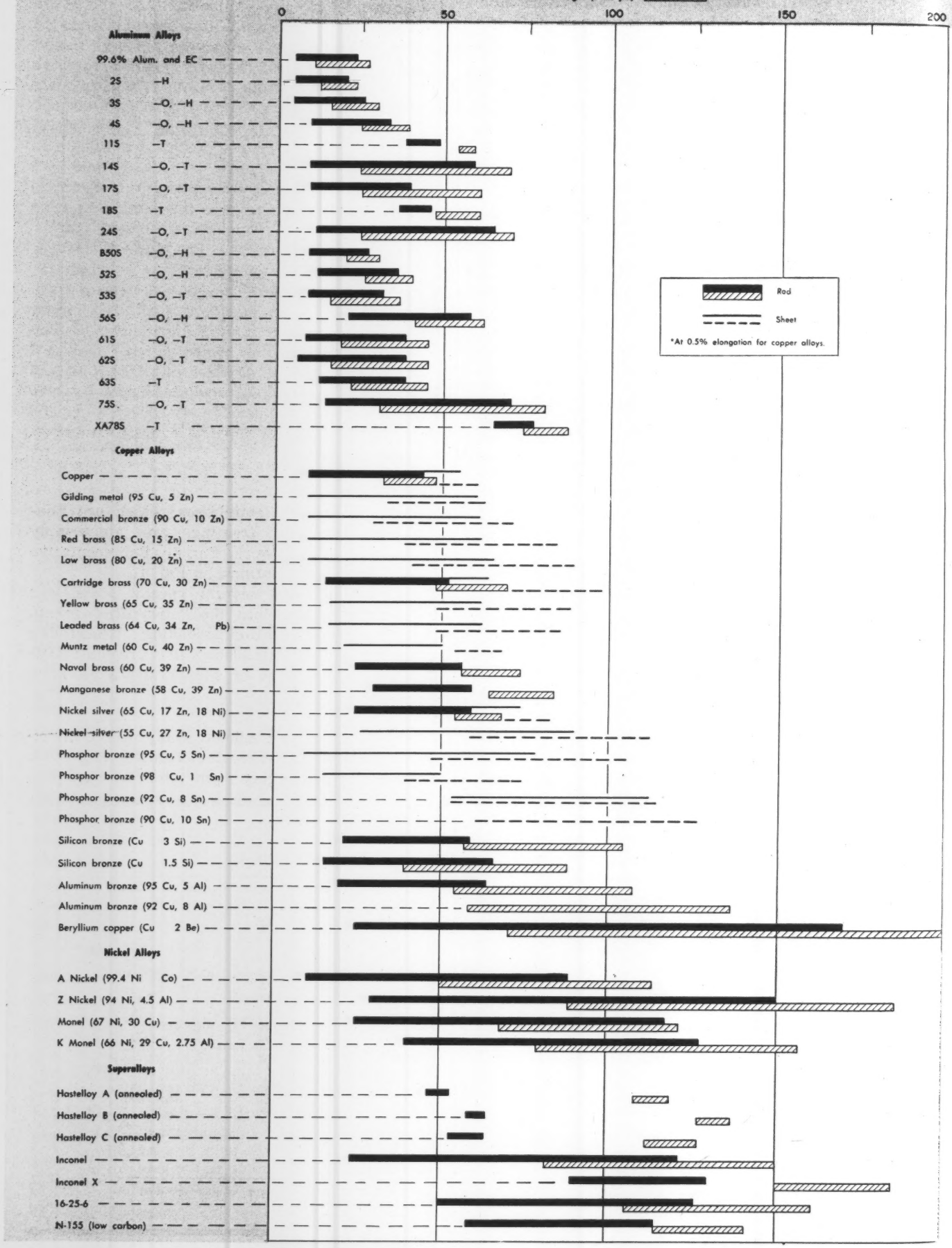


Table 2—Conditioning of Stainless Steels

Classification	Martensitic	Ferritic	Austenitic
Main alloying elements	Chromium, carbon	Chromium	Chromium, Nickel
Hardenable	Yes	No	No
Usual conditioning method	Heat treat	None or slight cold work	Cold work
AISI types	403, 410, 414, 416, 420, 420F, 431, 440A, 440B, 440C, 440F	405, 406, 430, 430F, 442, 443, 446	301, 302, 302B, 303, 304, 305, 308, 309, 310, 314, 316, 317, 321, 347

annealed strength of the alloy, *Fig.* 6. Like conventional steel heat treatment, solution heat treatment of aluminum alloys consists of raising the temperature of the alloy (910 to 1000 F) followed by a quench (usually in cold water for wrought alloys) which raises the strength to the desired level.

Following solution heat treatment, aging is necessary to "precipitate out" soluble constituents. During the aging or precipitation hardening treatment strength of the alloy increases to a maximum. Further aging or overaging causes a decline in strength until a fairly stable condition is reached.

In certain alloys—17S and 24S for example—precipitation hardening occurs at room temperature within a few days; consequently these alloys are usually naturally aged. In others—11S, 14S, 18S, 25S, 32S, 51S, 61S, and 75S—years would be required. These alloys require artificial aging—raising to a temperature of 250 to 375 F (for wrought alloys) for 4 to 10 hours.

Various combinations of solution heat treatment, aging and cold working are included in the —T temper designation for aluminum alloys. The —H temper designations denote strain-hardened or cold worked alloys, the degree of cold work or final hardness being indicated by the second digit. Thus —H12 is ¼-hard, strain hardened only; —H14 is ½-hard, —H16 is ¾-hard and —H18 is full hard. Similar designations are used for other combinations of strain hardening and conditioning. The effect of cold working on tensile strength is shown in *Fig.* 7.

Magnesium, Titanium and Nickel Alloys: Various grades of magnesium, titanium, and nickel alloys can be heat treated, the treatment usually consisting of solution heat treatment and/or age (precipitation) hardening.

Magnesium alloys, for example, are usually solution heat treated with an air quench or further artificial aging. Some grades of titanium can be heat treated by raising to temperature and air cooling (thin sections) or quenching (thick sections). In the case of titanium, however, present practice usually relies on cold working for strength increases.

Many different nickel alloys with widely varying compositions are available; consequently heat treatment cannot be summarized for all. The softest form of K Monel is obtained by water quenching; heat treating to obtain maximum properties consists of a single age-hardening treatment followed by slow, controlled cooling. By contrast, Z nickel requires a solution heat treatment preceding the single precipitation hardening treatment. Best treatment for Inconel X is considered to be a solution heat treatment followed by both a high-temperature (1550 F) and low-temperature (1300 F) aging treatment to develop the best combination of strength and ductility. Thus each case must be individually evaluated.

Copper Alloys: Most copper alloys act like pure metal and cannot be heat-treated; cold work is used extensively for strengthening—either by draw-

Table 3—Heat-treatable Aluminum Alloys

Not heat treatable		Heat treatable		
2S	52S	11S	24S	C57S
3S	A54S	14S	32S	61S
4S	56S	17S	A50S	63S
50S		18S	A51S	75S
		B18S	53S	76S

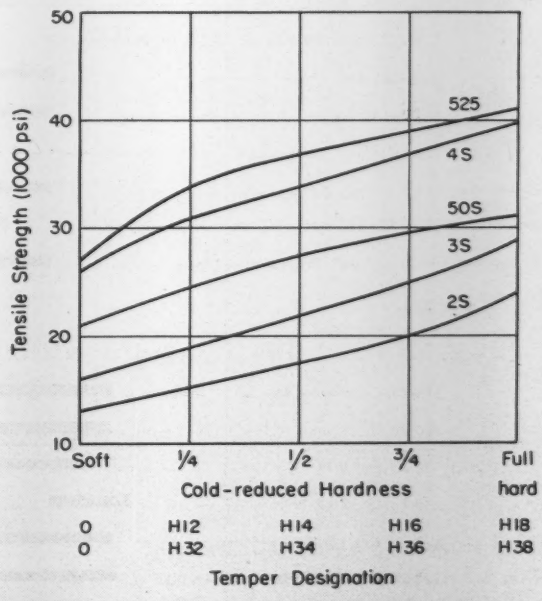
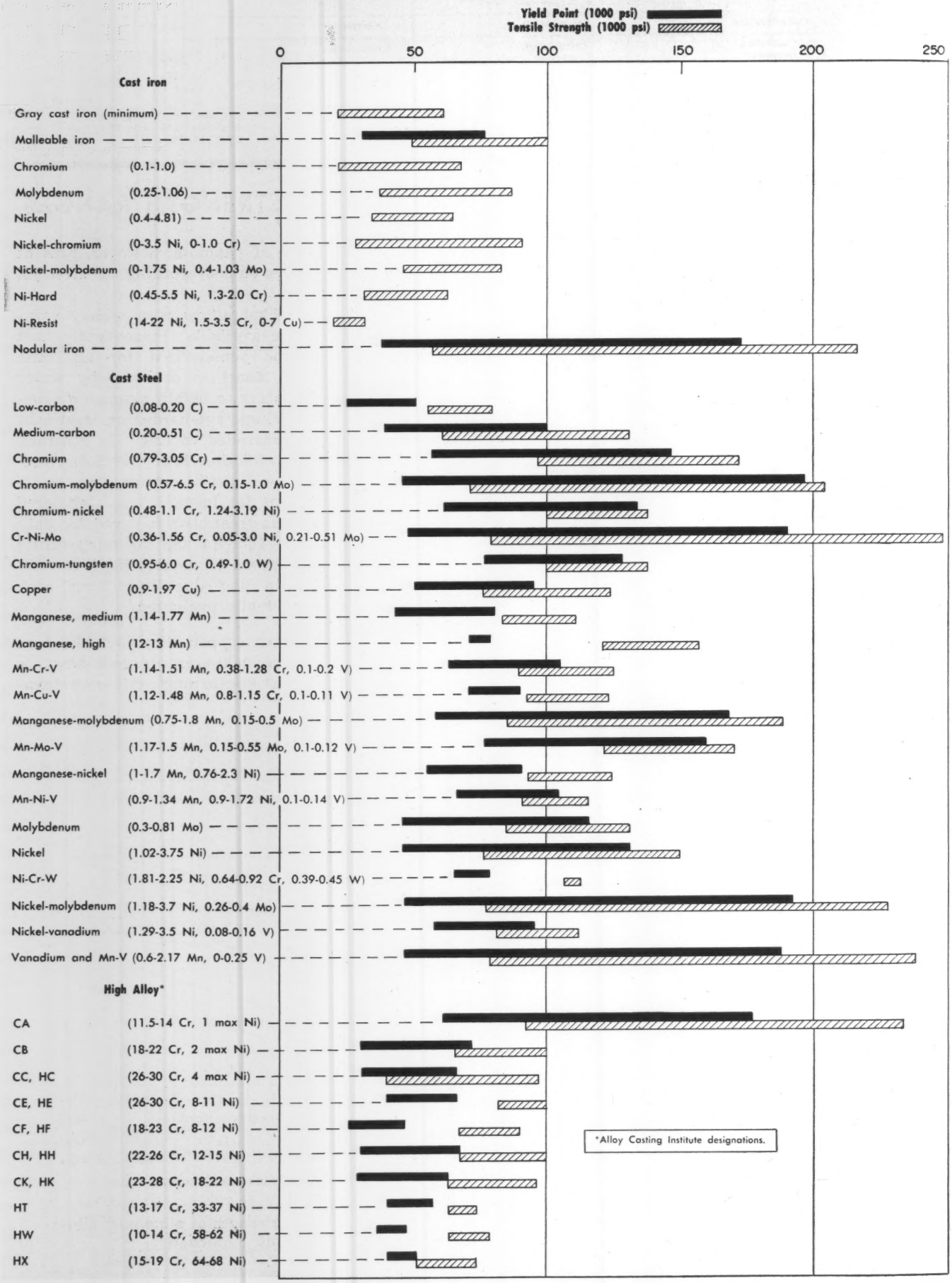


Fig. 7—Increase in strength of aluminum alloys by cold reduction

TENSILE STRENGTH RANGES

Fig. 8—Tensile Strength Ranges for Ferrous Castings



ing, forming or cold extruding. Typical increases in strength as a result of cold rolling are given in *Fig.* 7 of the previous article (November, 1953, Page 170). Typical strength ranges are shown in *Fig.* 6 of this article.

Based on tensile strength, copper work hardens at a rate of about 400 psi for each 1 per cent of reduction in area by drawing, yellow brass at about 880 psi, silicon bronze at 1100 psi, and several of the aluminum bronzes at 1400 psi. Thus, the variation is quite wide.

Exceptions to the rule on heat treatment are several precipitation-hardening alloys, which can be strengthened by a solution heat-treatment and precipitation hardening technique. These alloys are beryllium copper, nickel-beryllium copper, cobalt-beryllium copper, chromium copper, and nickel-phosphorus copper, most of which are 97 per cent or more copper. Additionally several aluminum-bronze alloys, available principally as hot forging alloys, can be heat treated.

Ferrous Castings: Ferrous casting strength ranges are shown in *Fig.* 8. Three broad groups—cast iron, malleable iron, and cast steels—differ in their response to heat treatment, and should be considered separately.

CAST IRONS: Cast irons suitable for heat treating have a graphite carbon content between 2 and 3 per cent, preferably of small particle size. Soft gray irons with coarse graphite and ferrite and high silicon do not improve in strength as much as lower-silicon pearlitic irons with smaller graphite particle size. Alloyed cast irons can often be quenched in an air blast or still air to secure the desired hardness; consequently, they may be used for more complicated shapes where a more drastic oil quench employed for plain irons might be detrimental. For highest tensile properties and shock-resistance, a tempering operation is included.

TENSILE STRENGTH RANGES

Actually, quenching from usual temperatures of about 1500 F reduces the tensile strength below as-cast values while hardness is increased, *Fig.* 9.[5] Tempering raises tensile strength as the draw temperature increases until a maximum strength, approximately equal to the as-cast strength, is reached. Beyond this tempering temperature, strength is again lower. At the tempering temperature producing maximum tensile strength, however, hardness remains substantially higher than original as-cast hardness.

MALLEABLE IRON: Standard malleable iron is used in the malleablized or annealed condition, in which it exhibits its well-known ductility and toughness. Exceptions are copper or copper-molybdenum alloyed malleable irons, which can be precipitation-hardened. Pearlitic malleable irons, however, can be direct-hardened by an oil quench and drawn to any desired hardness, but response is slower than for steel. With most malleable irons, such heat treatments are employed for hardening rather than raising the strength level.

CAST STEELS: Heat treatments used for cast steels resemble those for wrought steels. Low-carbon (below 0.2 per cent) steel castings do not respond readily to heat treatment, which is used only for annealing, refinement in grain size, and improvement of ductility. Medium-carbon steels, by contrast, are seldom used in the as-cast condition, improved tensile strength being obtained by an air quench, air quench and draw or liquid quench and draw. High-carbon (above 0.4 per cent) steel castings are usually quenched and drawn for applications requiring high strength and resistance

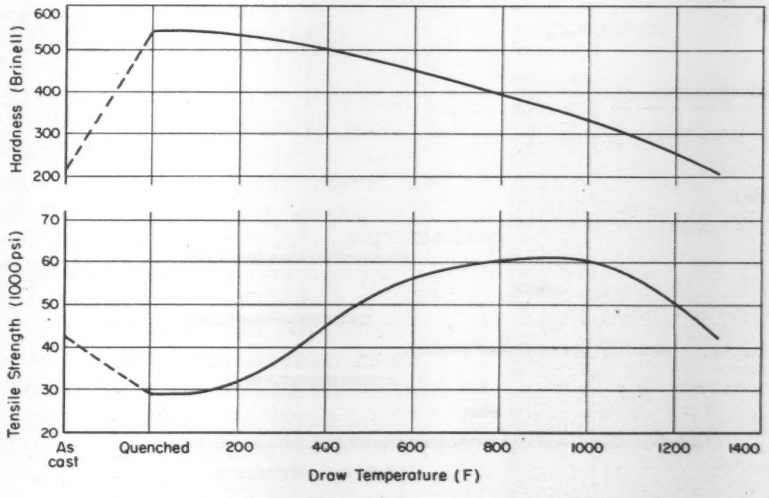


Fig. 9—Average variation in tensile strength and hardness of cast iron with draw temperature

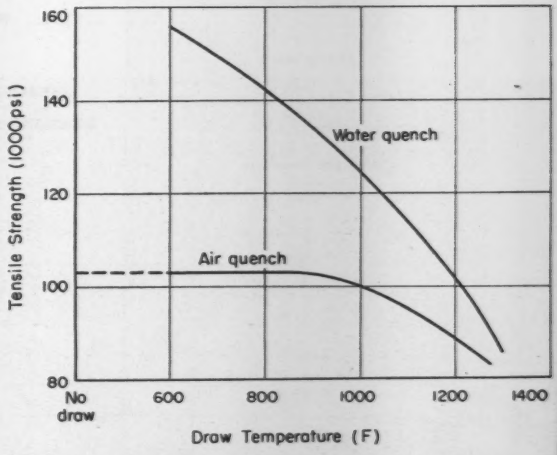


Fig. 10—Effect of quenching procedure and draw temperature on tensile strength of a medium manganese-molybdenum cast steel. Test castings were first heated to 1650 F

to abrasion. Form cannot be too complex nor size too large because of the danger of quench cracking.

Alloy cast steels, like wrought alloy steels, are designed to be heat treated. Hundreds of different alloy combinations and heat treatment schedules are available to bring out the best properties of the alloy steel. Effects of two different quenching procedures on the tensile strength of a medium manganese-molybdenum steel are shown as an example in *Fig.* 10.

Nonferrous Castings: Cast nonferrous metals, with strength ranges shown in *Fig.* 11, resemble their wrought counterparts in that solution heat treatment and precipitation-hardening methods are used for improving strength level. Thus, the copper alloys previously listed are capable of strength improvement as castings.

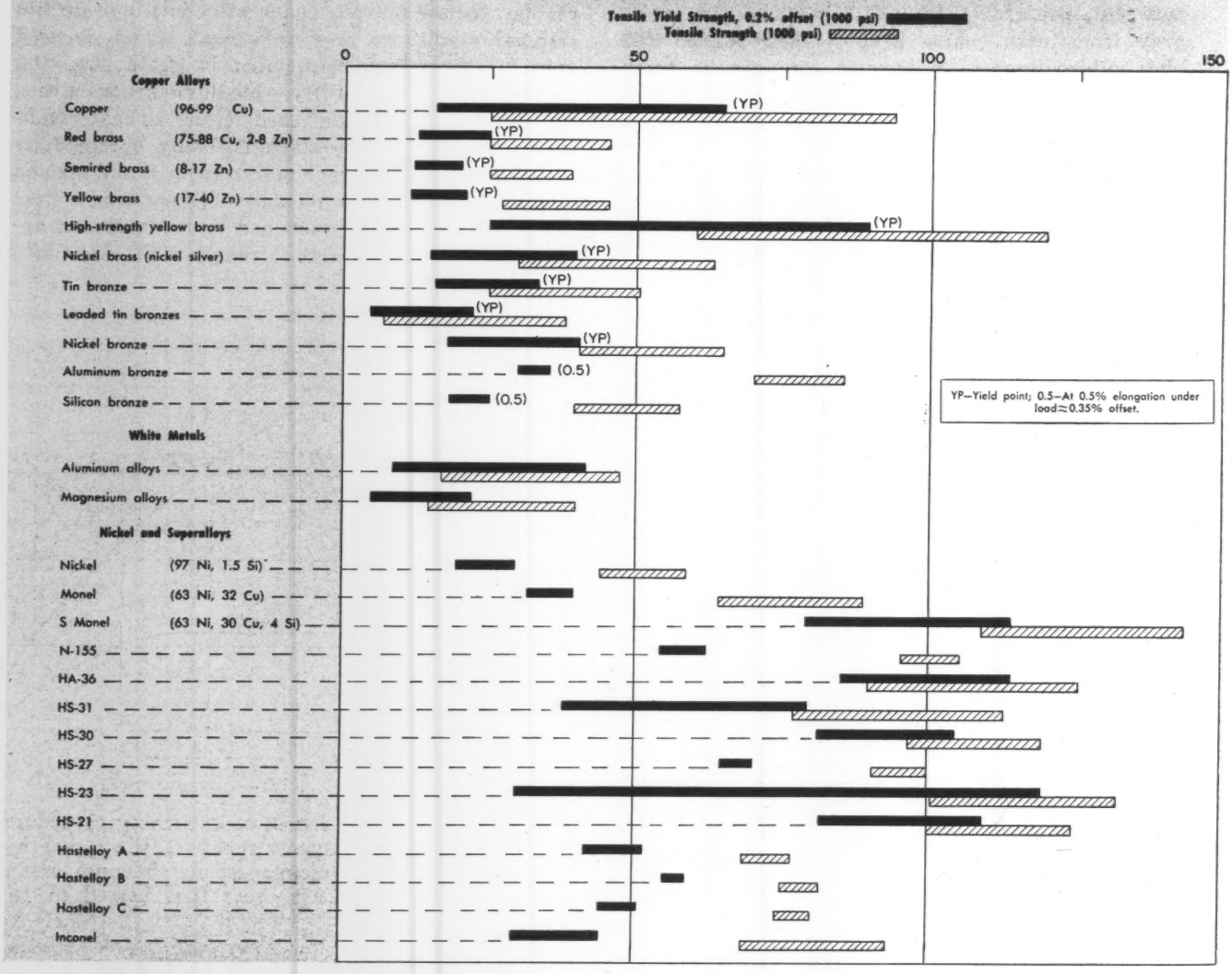
Many of the aluminum casting alloys are also capable of being heat treated by the same procedures. For certain intricate castings, which cannot be quenched without causing quenching strains, a precipitation treatment only may be used. Magnesium-base alloys are similarly treated, solution heat treatment being used to increase tensile strength, per cent elongation and toughness. Subsequent precipitation heat treatment or aging increases yield strength and hardness, with decrease in per cent elongation and toughness.

Plastics: The tensile strength properties of plastics are extremely susceptible to many influences; consequently actual strength of a part may be quite different from property test values. Mold design and gating, amount of plasticizer or filler, and temperature all have a strong effect. For thermosetting compositions, polymerized during molding, tensile strength is also dependent upon molding technique.

Percentage of plasticizer—necessary to obtain proper flow during molding for many plastics—alters physical properties. A highly plasticized, soft material having easy molding properties has lower tensile strength than the same material in harder, less plasticized grades.

Fillers do not appreciably affect tensile strength

Fig. 11—Cast Nonferrous Metal Tensile Strength Ranges



in small quantities; when present in large proportions they can either increase or decrease tensile strength. Cord, chopped fabric, glass fibers and similar fibrous materials usually increase tensile strength. Granulated or powdered fillers, such as mineral flour, whiting, diatomaceous earth, are usually added to change coloring or opacity, or to sharpen definition of molded edges. Such fillers can decrease tensile strength if present in sufficient quantity.

Temperature has a much greater effect on strength of most plastics than on metals. Normal temperate-zone atmospheric temperature variations have but little effect on metals, but plastics are affected to a great degree. Humidity also plays a part, although atmospheric relative humidity changes cause less significant differences.

Mold design, and particularly gating, vary actual strength. A molded test bar gated at the center rather than at one end usually has significantly lower tensile strength. "Weld marks," where two flow channels in a molded part meet, indicate areas of significantly lower strength, and tensile strength at right angles to highly directional flow lines is usually lower. Variations in density throughout the molded part may cause weak points.

Adequate cure, of course, is primary in all thermosetting plastics, since strength is directly dependent upon polymerization (formation of molecular chains) of the resin.

Rubber and Elastomers: Ultimate tensile strength or breaking strength of elastomeric materials usually have little practical significance, since such compositions may elongate 700 per cent or more before breaking, whereas actual conditions may call for much less deflection. Usual practice for rubber, therefore, calls for the tensile strength properties to be stated as a per cent modulus (usually 300 or 400 per cent) indicating the tensile stress at the stated per cent elongation.

Most rubber and elastomer parts are not used in tension—shear or compression being more usual. Tensile values are thus not too applicable. Additionally, the relationship between tensile properties and other properties is rather haphazard, so tensile properties are seldom related to serviceability. The main use of tensile tests is to estimate the deteriorating effects of heat, chemicals, etc. Variations in tensile strength are indicative of such changes.

Summary: Strength in tension, as an indicator of strength level of a material, is a basic consideration; ranges of tensile strength possible as a result of heat treatment and cold working have been indicated. But other factors also have a bearing on "strength." Ductility, or the ability of the material to readjust to slight deflections, may be important. Primary loading may be in compression, torsion, shear or flexure rather than in tension, and the material's behavior under these conditions may be different. Impact strength, "crackless plasticity" or other characteristics of the material may have a bearing on overall evaluation of strength. These additional factors will be considered in future articles.

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3. A. L. Boegehold—"Selection of Automotive Steel on the Basis of Hardenability," *Hardenability of Alloy Steels (Contributions to the Metallurgy of Steel—No. 11)*, American Iron and Steel Institute, New York, 1944.
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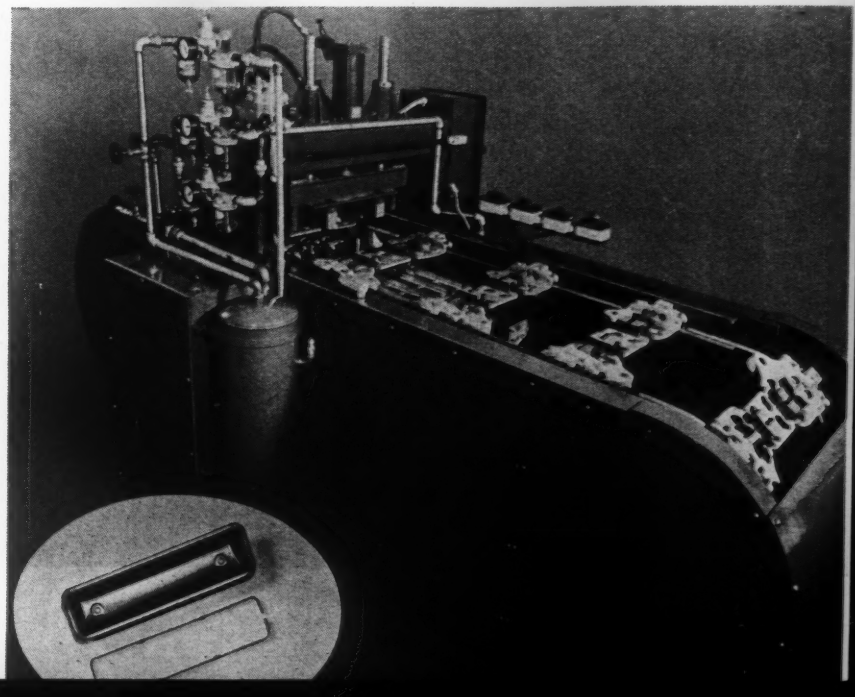
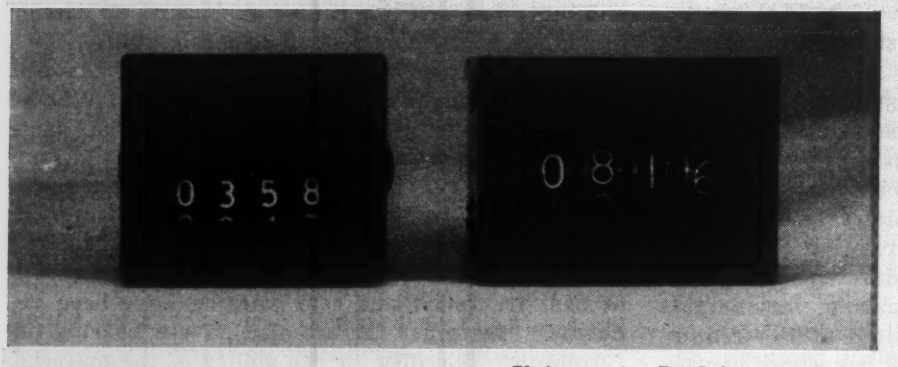
CONTEMPORARY DESIGN

Welding Machine

A CONTINUOUS chain conveyor carrying 12 fixtures permits continuous loading and automatic indexing of valve gasket covers on a new welding machine developed by Multi - Hydromatic Welding & Mfg. Co. Twelve spot welds fasten retainers to the covers at a rate better than 600 units per hour. Fixtures are moved intermittently to position by an air cylinder; positive location being obtained by indexing against a movable, air-operated stop pin. At the welding station, an air clamping cylinder exerts a downward force, pushing the fixture onto locating pins, and the valve cover over the weld backups.

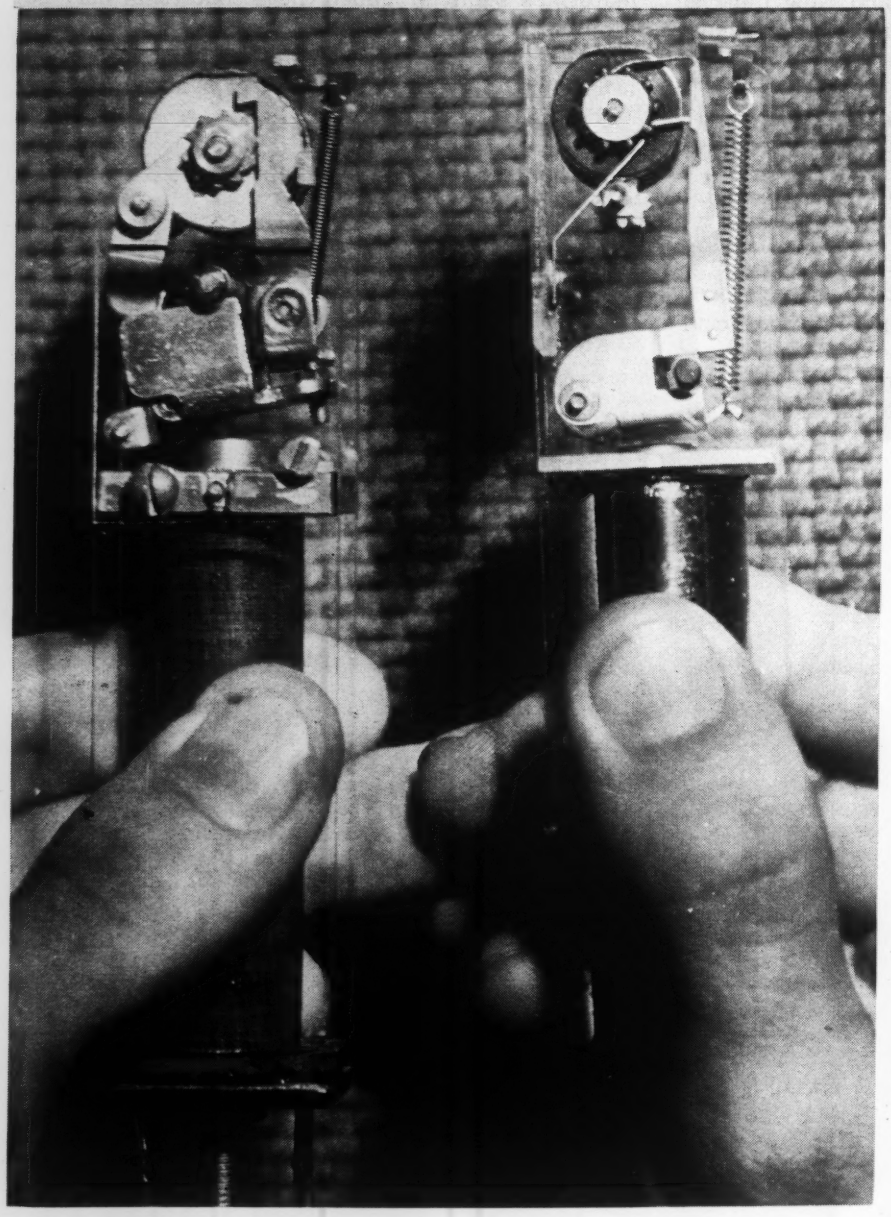


Redesigned Message Register Has Fewer Parts



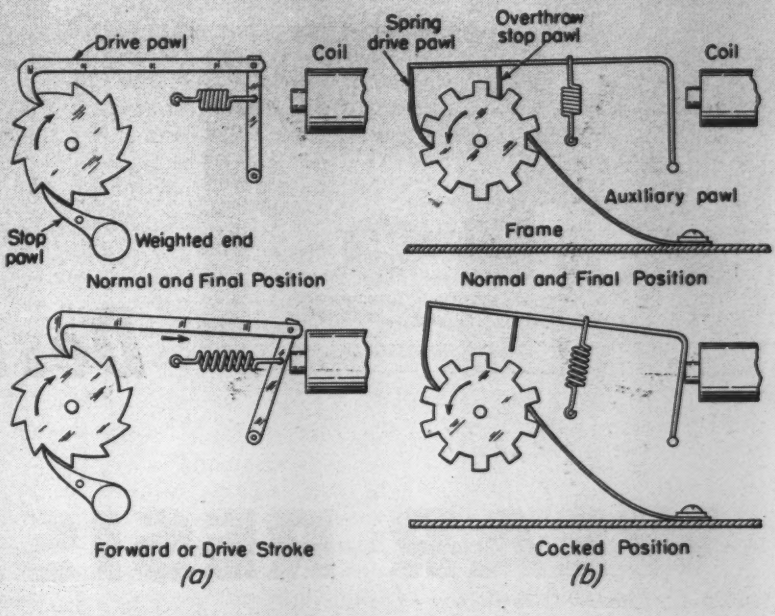
Photos, courtesy Bell Laboratories Record

COMPLETE redesign of the new 14-type message register, left, from the older 5-type, right, has resulted in a reduction in parts from 70 to 40, reduction in size, and faster operation. Additionally, the new register design by Bell Telephone Laboratories Inc. has a life expectancy of over 2 million counts without a miscount, compared with about 500,000 for the older 5-type. Height of both registers is the same, but the 14-type is narrower and more than an inch shorter in length. Weight is 8 ounces, half that of the older type.



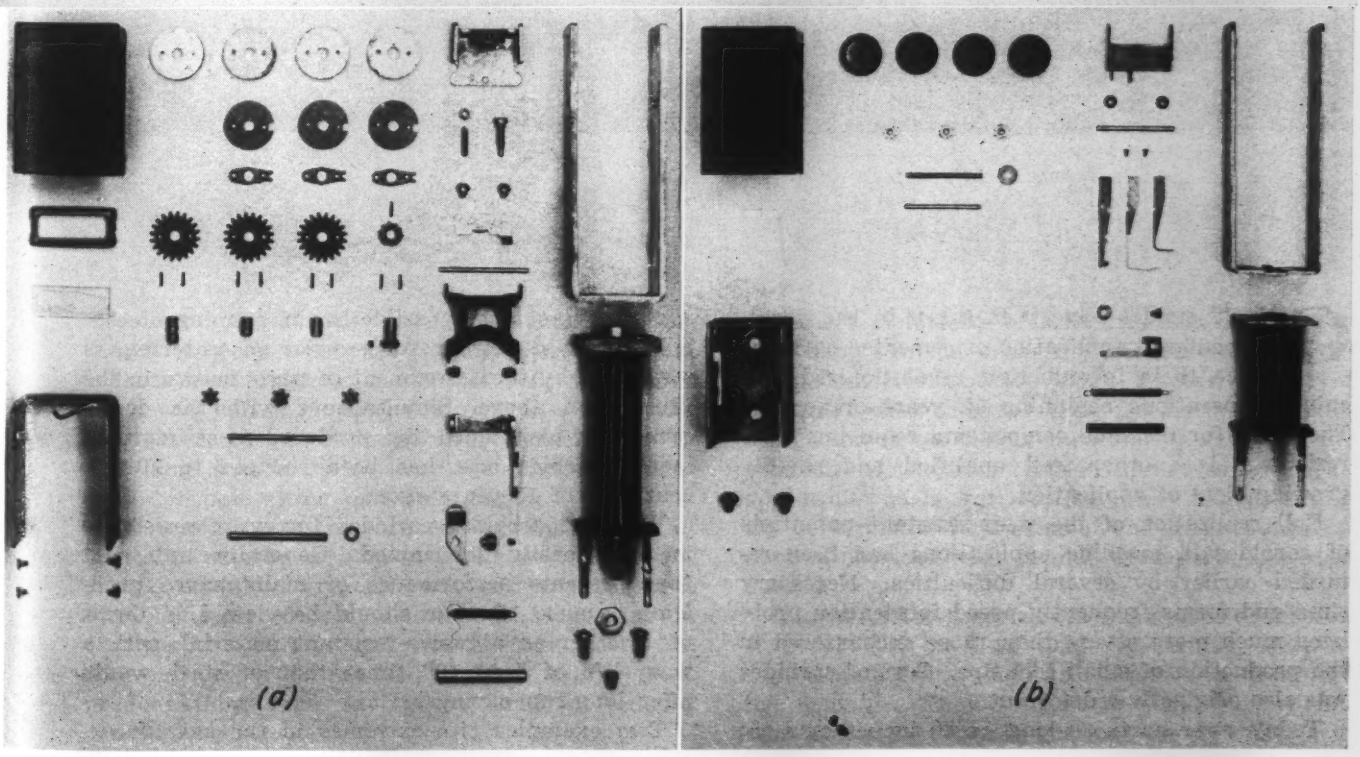
Simplicity of the new type, right, is evident by comparaison with its predecessor. Several advantages are gained by the new design. Arrangement of the drive pawl, plus lighter weight of the number wheels, permit much faster operation. Unlike the previous model, pawls on the new 14-type are not weighted, and will operate at angles greater than 45 degrees. Consequently, the register may be mounted in any position.

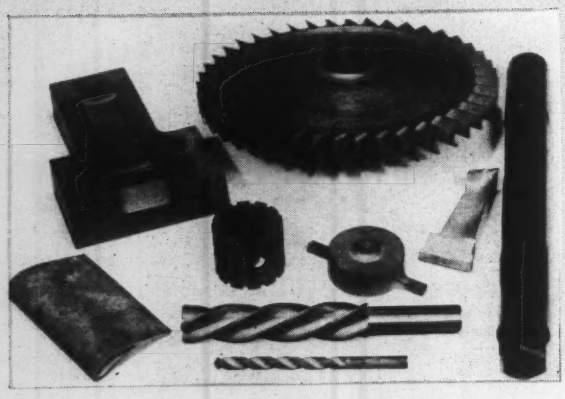
Basis for weight and size reduction is a new drive system. The older 5-type uses a forward drive system, *a*, in which the pawl advances the ratchet one digit when the electromagnet pulls the armature toward it. The stop pawl is held against the ratchet wheel by gravity, since it is weighted at one end. Gravity also holds the drive pawl in position. A fixed overthrow stop and the shape of the drive pawl prevent unwanted forward motion.



By contrast, the back drive system, *b*, used on the new 14-type drives on release of the magnet. Motion of the armature when attracted by the magnet "cocks" the drive pawl by tilting it upward, and also releases the overthrow stop pawl. On release, the cog ratchet is advanced one digit, and the overthrow stop pawl intercepts a tooth to stop the action.

Reduction in number of parts is very evident. Many parts have been eliminated by using molded black nylon for the number wheels and drive gears, and others by the simpler armature assembly. In the earlier register, *a*, each number wheel was riveted together from several parts. In the newer register, *b*, the single molded wheel includes all gears, bearings and other parts.





Designing for WEAR RESISTANCE with Cemented Carbides

By F. J. Lennon Jr.
General Superintendent
Kennametal Inc.
Latrobe, Penna.

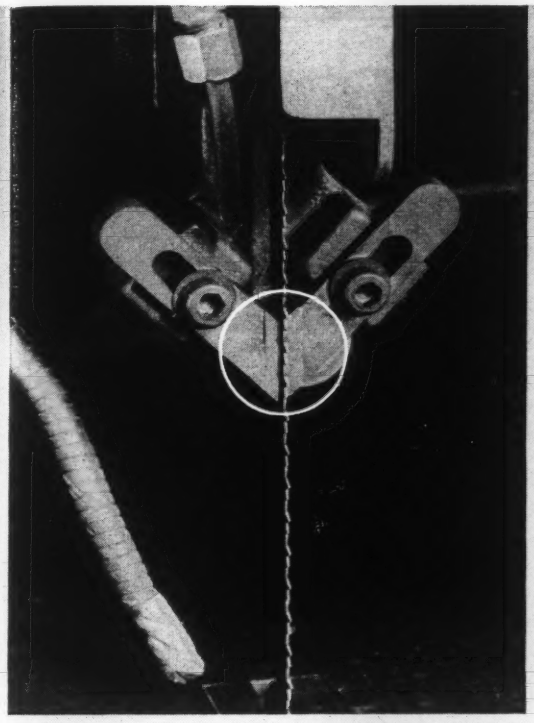
GREAT strides have been taken in the development and application of cemented carbides since their introduction revolutionized machining operations beginning 15 years or so ago. Their use for machine components requiring wear resistance is another well qualified and rapidly growing field of application.

Full realization of the wear-resistant potentials of carbides in machine applications had been retarded earlier by several difficulties. Necessary sizes and forms frequently posed fabrication problems much more severe than those encountered in the production of small tool tips. Cost of carbides was also originally a deterrent.

Today wear parts as long as 30 inches or more can be made without difficulty. With respect to contour, versatility possible in the shaping of carbide parts in powder form, prior to sintering, is suggested by the assortment of parts shown in the illustration above. Simultaneous with the development of techniques that produced these improvements, carbide cost has been reduced to 10 per cent that of 15 years ago.

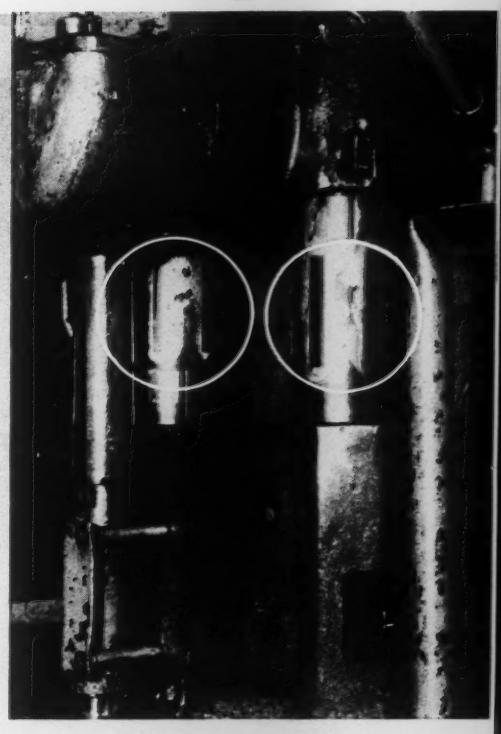
When to consider carbides for wear resistance is often easily determined. Generally, any part that presents performance or maintenance problems because of wear should be viewed in terms of whether an abrasive-resistant material, with a wear life of 5 to 100 times that of steel, would offer long-run savings.

Two examples cite extremes in the use of carbides for wear-resistant parts. An extreme in

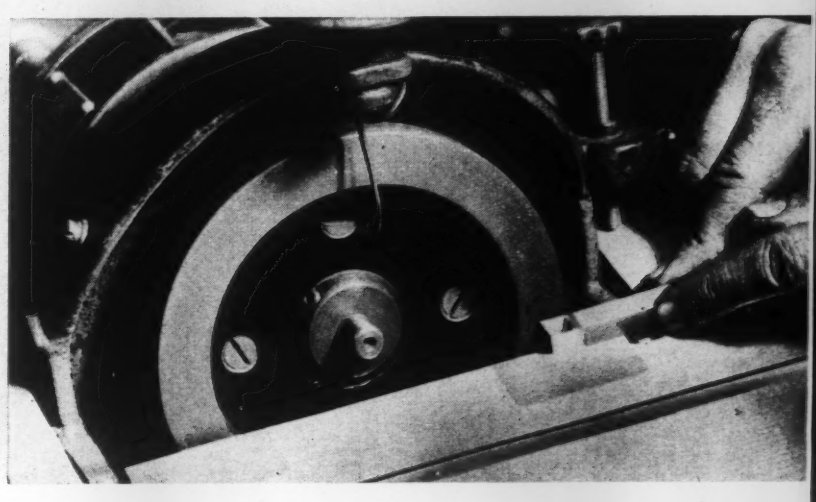


Left—Band-saw guides had worn excessively in the processing of abrasive work until carbide wear strips were incorporated. This adaptation of wear surfaces proved quite effective, yet was extremely simple and inexpensive

Right—This hand milling machine is so employed in production that sliding of the table supports takes place repeatedly at about the same position on the posts. This somewhat abnormal service induced rapid wear and resulting inaccuracy. Carbide strips brazed to the posts solved the problem



Right—Rough and finish grinding of carbide tools presented a problem in table wear until carbide wear strips were adapted. Also, a hazard was eliminated. Broken grinding wheels and personal injury had occurred previously because steel tables had tended to become rough when worn and the work would be torn from the operator's hand

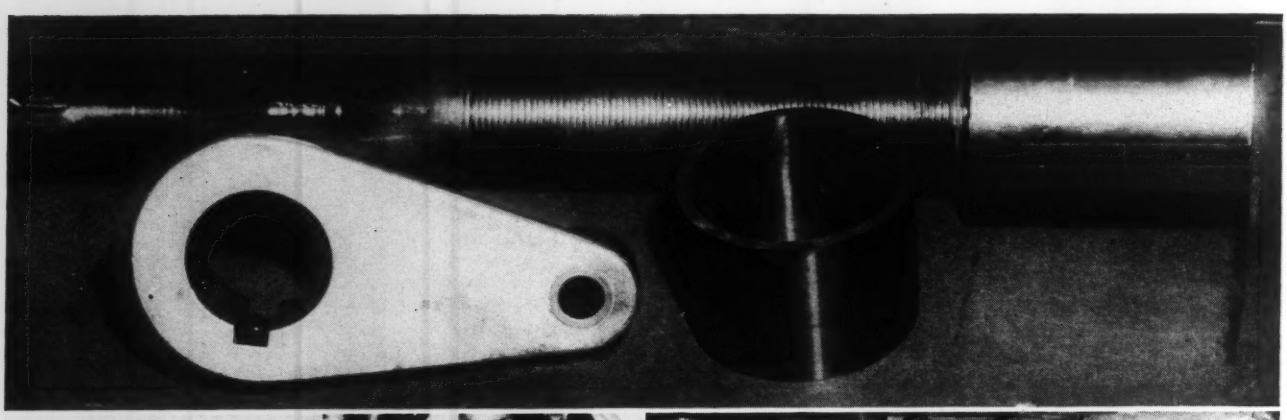


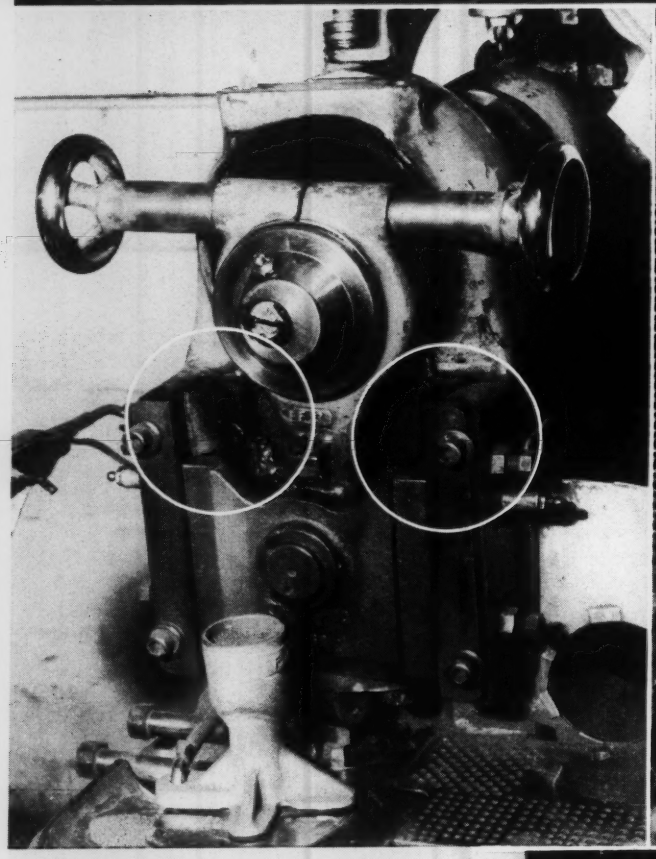
simplicity, carbide balls are used in Brinell testing machines because they give accurate and consistent indentations longer than conventional steel balls. As check valves in pumps and in oil-well service they have shown prolonged life. Incidentally, for the same reason, these simple elements are also used for hole sizing and hole gaging.

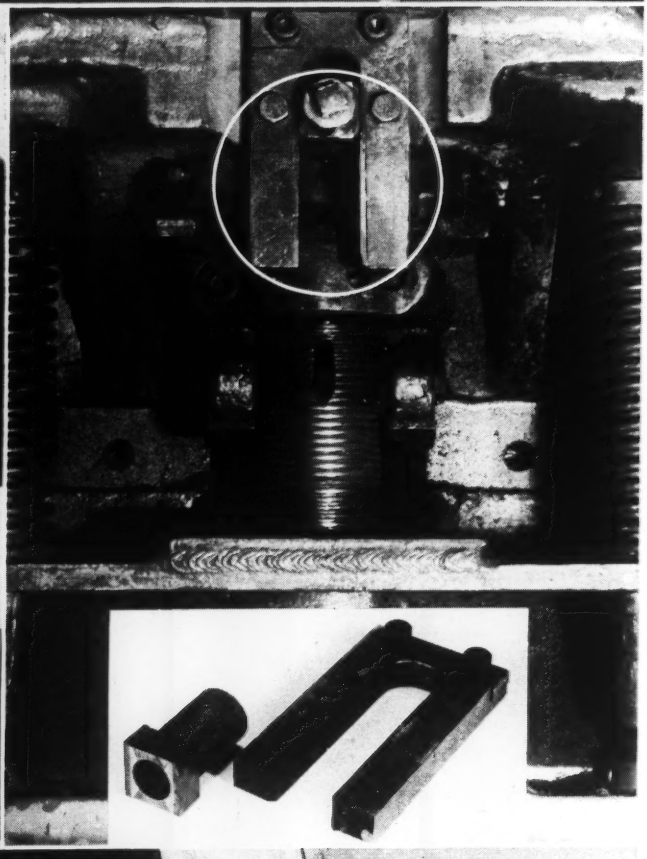
At another extreme are rolling mill guides of titanium carbide, a heat-resistant as well as abrasive-resistant composition. Guides that were formerly replaced every 1 to 8 hours, depending on the application, now run two to four weeks before redressing is necessary. This improvement produced impressive savings by virtue of reduced downtime.

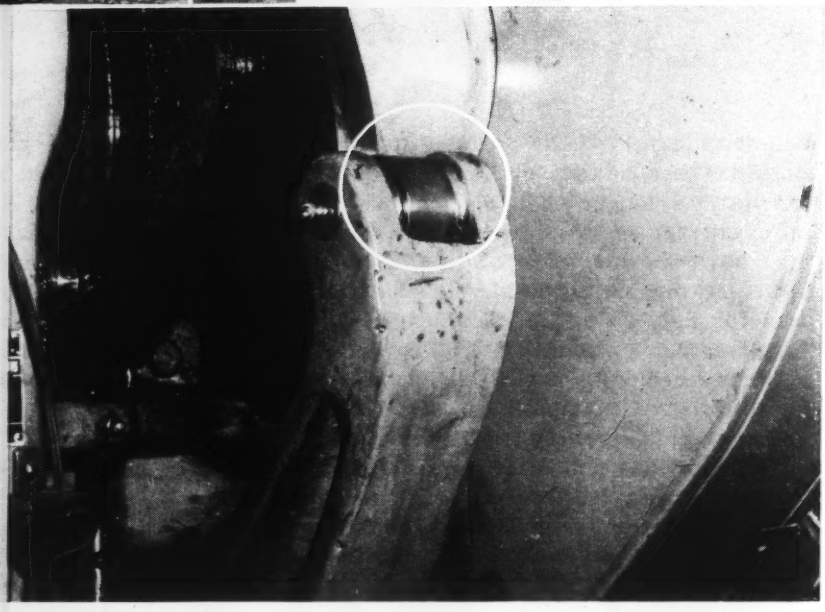
Additional applications of carbides for wear parts are pictorially presented in this article. The uses shown are in most cases actual examples developed in Kennametal's plant. Excessive wear of machine parts occurred possibly more frequently than common because of the abrasive nature of the product. However, such service proved to be an admirable basis for testing and demonstrating the performance improvement and maintenance reduction obtained with carbide wear parts and wear inserts.

In most of the cases shown wear parts or inserts, of grade K-6 or K-12 tungsten carbide, were adapted with few or no basic changes in design of the machine. They suggest in some variety the possibilities that can be realized when attention is focused on wear and its alleviation.



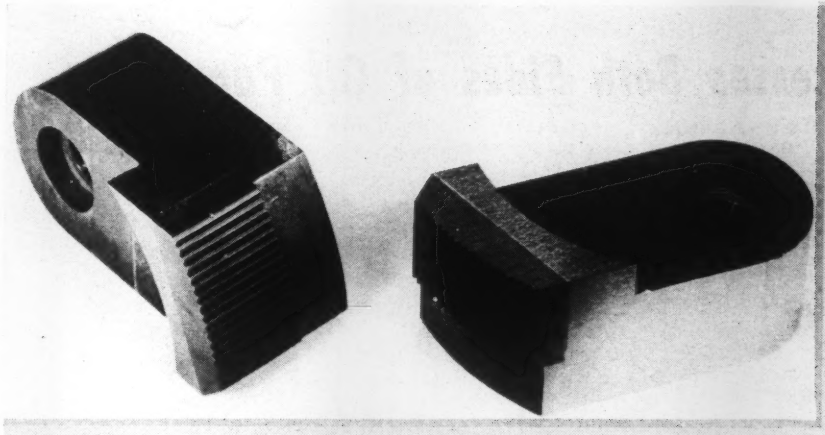




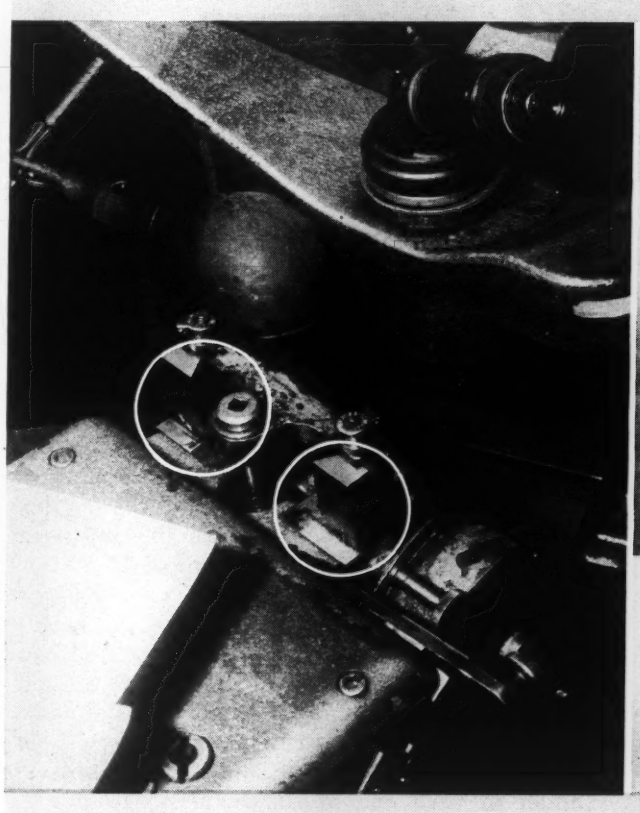


Certain contact components in carbide tabletting presses are subjected to severe service in the processing of millions of blanks yearly. Downtime and overhaul resulting from wear in such presses have been almost completely eliminated by the introduction of—top—carbide sleeves in the top ram mechanism; above — carbide slide plates; above right—carbide wear plates on the ram guides; and right—carbide cam roller

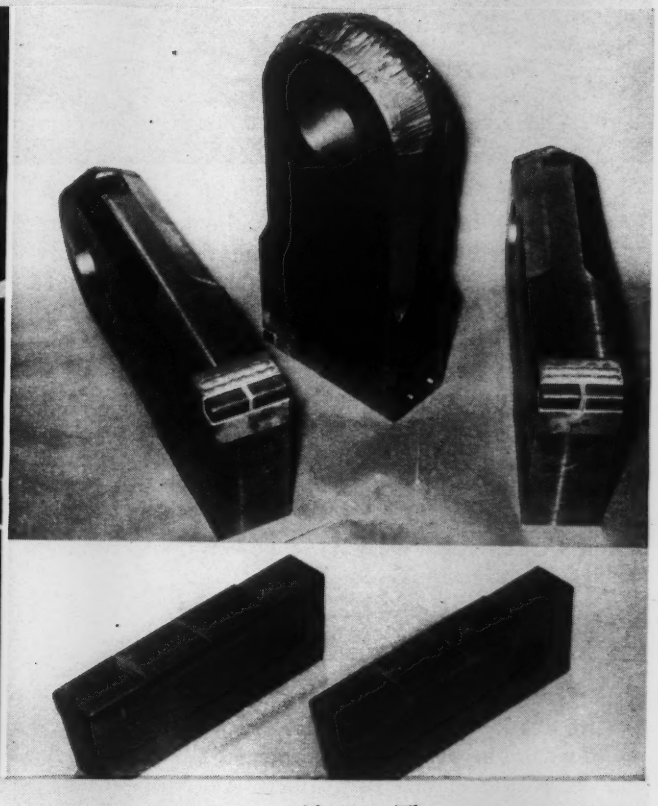
DESIGNING FOR WEAR RESISTANCE WITH CEMENTED CARBIDES



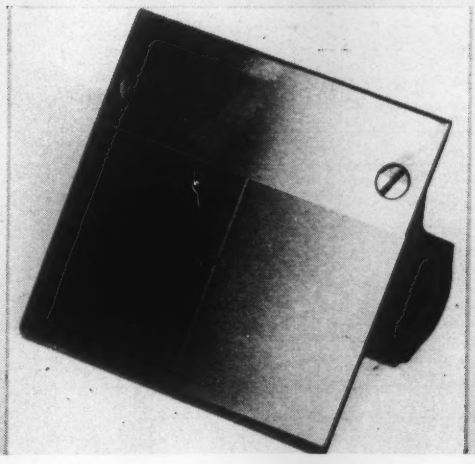
Left — Tipped with carbide, these automatic-lathe chuck jaws eliminated slippage and spoiled parts in an automotive plant. Average steel jaw life was 3,750 pieces. After 150,000 pieces, equivalent to 40 steel-jaw changes, the carbide-tipped jaws showed no appreciable wear and were kept in service



Above — Precision has been maintained and frequent overhauls eliminated by the use of carbide slides on this optical form grinder. Cost of carbide gibs proved less than the expense of one overhaul

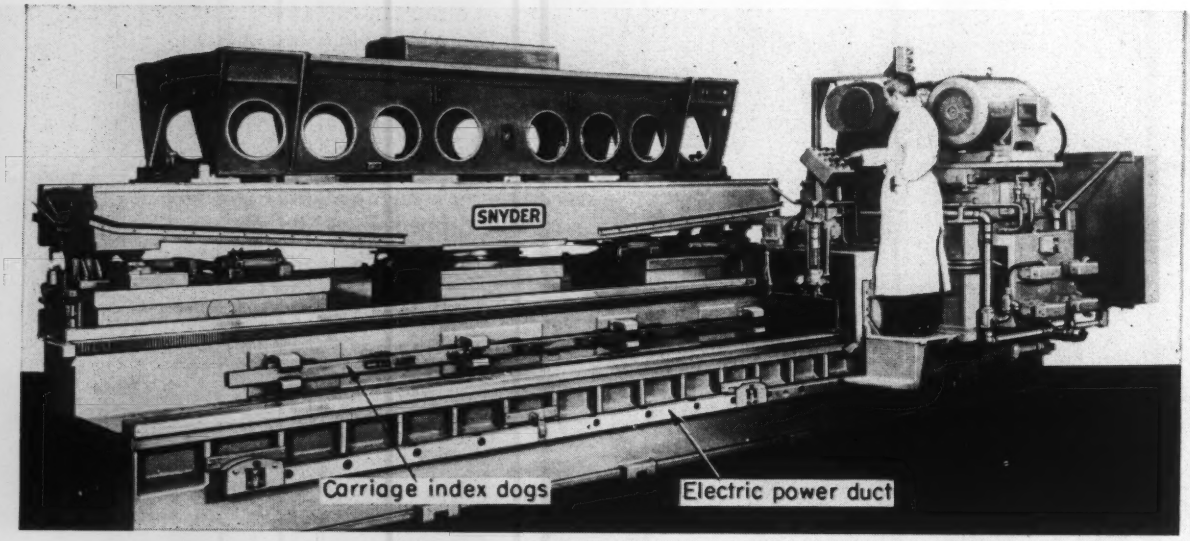


Above—These two types of pulverizing hammers show how carbide tips can be added to prolong hammer life. In one typical application, steel hammer life was 10 days with a daily mill production of 18,000 to 20,000 pounds. Tipped hammers lasted 8 months, daily production was increased to 22,000 pounds, and 5 million pounds were produced in the 8-month run. Hammer cost was $1.632 per ton with steel hammers, $0.223 per ton with carbide-tipped hammers



Right — Carbide-faced platen adopted on Hammond abrasive-belt finishing machine eliminated grooving of the platen when the machine is used for such work as tool sharpening

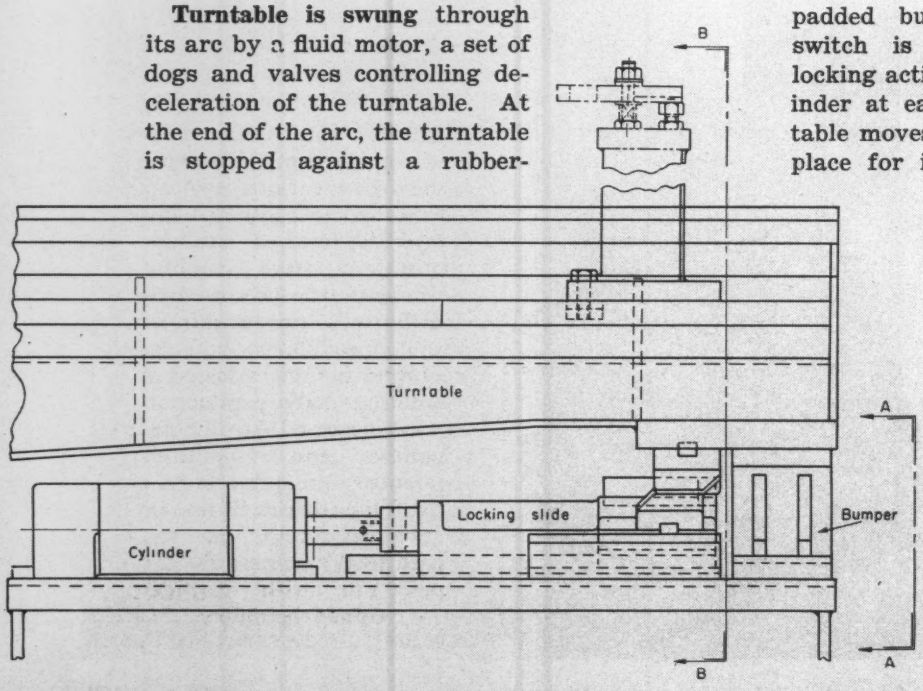
Special Machine Processes Both Sides of Oil Pan

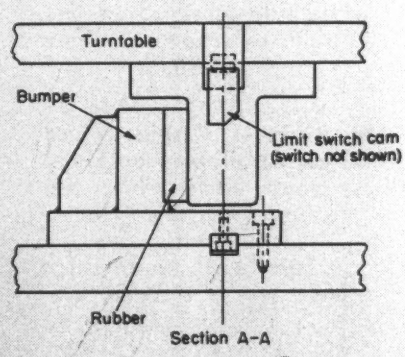


BOTH sides of welded-steel diesel-engine oil pans are processed by a semiautomatic special-purpose machine developed by Snyder Tool & Engineering Co. A turntable swings a fixture and the oil pan through a 180-degree arc so that hand-hole openings can be bored and faced on each side. A hydraulically operated feed unit, mounted on rails running the full length of the 267-inch long machine, is indexed from station to station by a fluid motor driving the carriage through a pinion and rack attached to the base. Power to the carriage is fed through a trolley type power duct running the length of the machine.

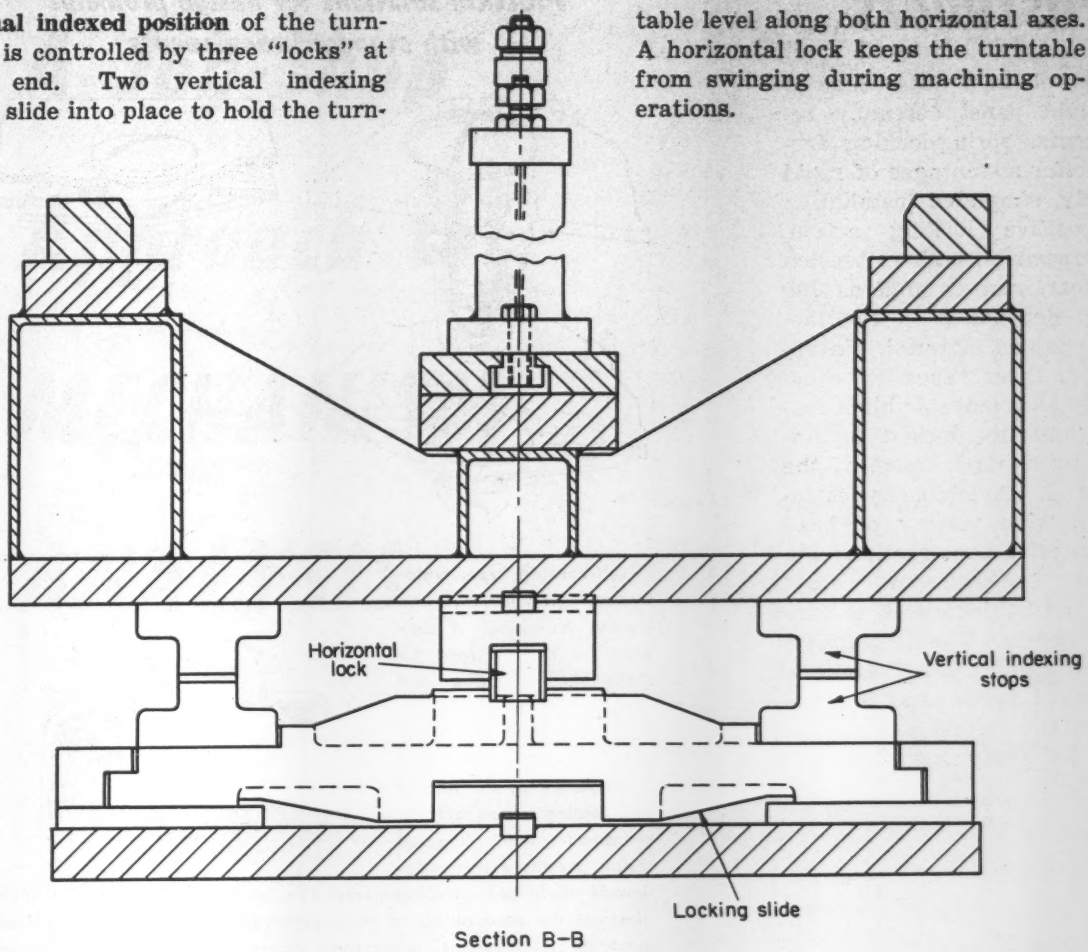
The operator has a choice of automatic or manual operation. On automatic operation, the carriage indexes to each successive work position from left to right. After the carriage indexes to extreme right, the fixture is rotated, and the opposite hand-holes are machined from right to left. On manual operation, each index and cutting cycle must be initiated by the operator. Electrical controls are interlocked so that the fixture cannot be rotated until the carriage is clear and the carriage cannot be moved until the turntable and fixture are in the proper position. A maximum of 16 stations may be used.

Turntable is swung through its arc by a fluid motor, a set of dogs and valves controlling deceleration of the turntable. At the end of the arc, the turntable is stopped against a rubber-padded bumper, and a limit switch is tripped to initiate locking action. A hydraulic cylinder at each end of the turntable moves a locking slide into place for indexing position.



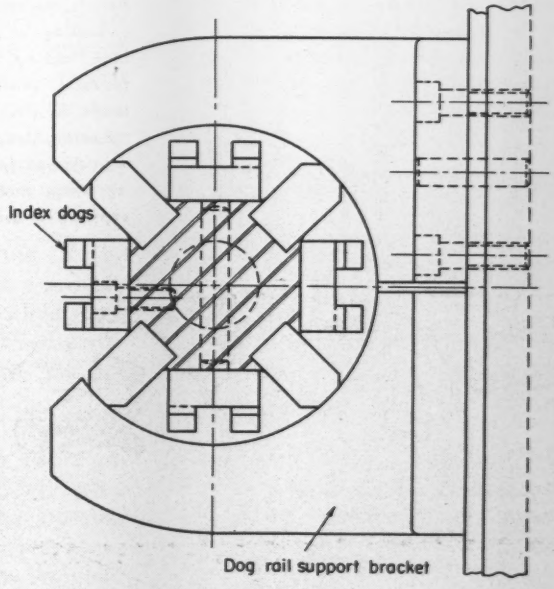


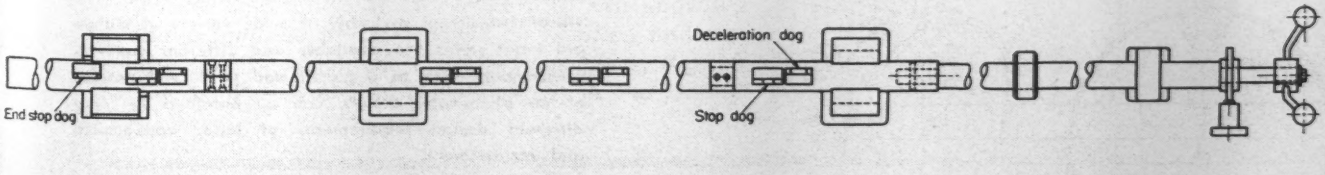
Final indexed position of the turntable is controlled by three "locks" at each end. Two vertical indexing stops slide into place to hold the turntable level along both horizontal axes. A horizontal lock keeps the turntable from swinging during machining operations.



Section B–B

Hand-holes for 6, 8, 12 and 16-cylinder oil pans and crankcases can be handled on the machine even though center distance between cylinders differs on the various parts. A dog rail, on which stop or index dogs corresponding to the positions of hand-holes in the part being run are mounted, can be rotated to one of four positions. Thus the carriage position is indexed to the proper cylinder spacing for any of the four parts.



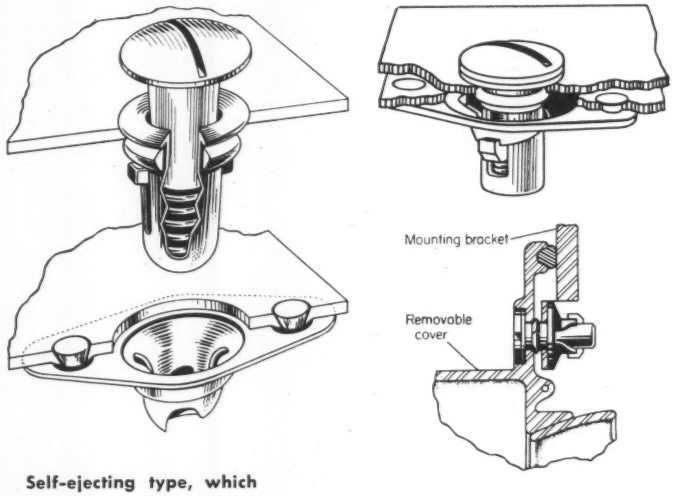


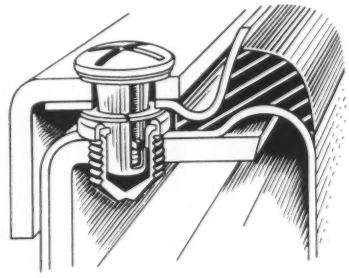
DESIGN DETAILS

Practical solutions for design problems with standard components

Spring-Locking Fasteners

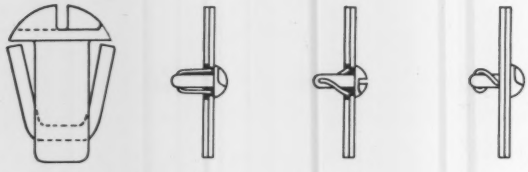
Adaptable to a wide range of sheet and panel assembly requirements, spring-locking fasteners offer advantages of rapid assembly, simplified installation and positive locking action. Load capacities, both in tension and shear, run as high as 700 pounds, depending on the fastener type and material. In application, these types serve essentially as removable blind fasteners and are locked or unlocked by a partial turn of the main stud. Available types include a wide variety of head and material constructions applicable to different sizes, shapes, and thicknesses of panels and sheets. The accompanying illustrations show some of the typical types, and applications, of the fasteners manufactured by Simmons Fastener Corp.

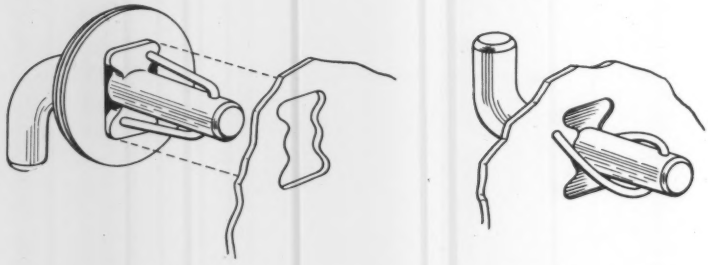


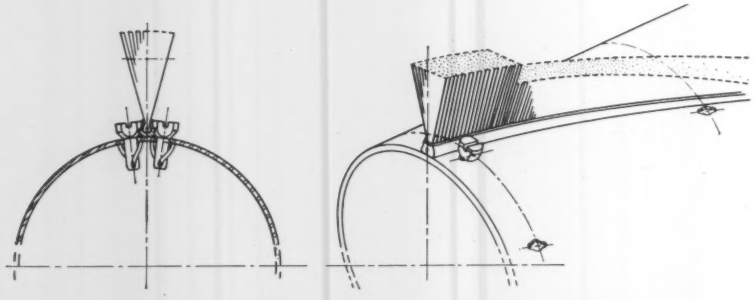


Self-ejecting type, which has spring-loaded stud and mating receptacle, is suitable for curved sheet installations. Mounting and removal of detachable panels are facilitated by the inherent self-aligning characteristic of the fastener. Floating action of stud combined with tapered shape permits accommodation of slight hole misalignments. The two typical applications shown illustrate the adaptability of these types of fasteners to meet different mounting requirements, particularly where a rugged, sealed construction is desirable.

Locking or unlocking is accomplished by 90-degree rotation of stud; high locking torque is provided by camming action of dimple on receptacle. Initial loads are carried by the helical spring and increased loads by the solid supports, assuring minimum deflection. Receptacle mounting may be achieved by means of threads, riveting, or welding. Adjustment for variations in panel or sheet thickness is accomplished by using receptacles of different depth or, when the screw type receptacle is used, by changing the relative depth directly.







Self-adjusting type is ideal for blind fastening applications and compensates automatically for variations in thickness of materials being used. Load capacities are not as great as for the self-ejecting type; however, these fasteners do offer advantages in cost and ease of installation. Typical applications show multipurpose usefulness as a fastener or as a support.

A quarter turn locks or unlocks the fastener which can be utilized for either removable or permanent installations. Locking is accomplished through a spring loading action, without deflection, which affords a vibration-resistant assembly. A wide variety of standard head styles are available and different material constructions such as a plastic and steel combination, or an all plastic design, can be obtained to meet different design requirements of load, appearance and environment.

A Job-Shop Approach to MECHANISM ANALYSIS

Special methods of analyzing motions in linkages and other mechanisms offer short-cuts and a certain degree of elegance but sometimes tend to obscure the physical nature of motion. Furthermore, mastery of the techniques takes time which many engineers feel they cannot afford on a one-shot basis. The engineer has to "tool-up" his mental equipment for these "mass-production" methods. This article presents a practical approach to motion analysis which parallels a job-shop operation in that the actual method is not highly engineered but does permit the engineer to go right to work on his problem, using concepts and fundamentals that are basic and not too unfamiliar. It has the advantage that at all stages the engineer can see what he is doing, and can picture what is happening

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BY CLASSICAL definition, a machine is a device in which motion, energy, or material is converted from one form into another. In almost all machines motion is basic and the engineer must be competent to analyze it if he is to design the machine properly. A high percentage of the motions occurring in machines take place in a single plane, the category to be discussed in this article.

Definitions and Concepts: Understanding of the definitions of displacement, velocity, and acceleration together with the concept of the so-called rigid body is the basis for the solution of all motion problems. Certain definitions are essential to this understanding:

Position of a point in a plane is fixed if two quantities are known. The rectilinear and the polar coordinate systems, *Figs.* 1 and 2, are widely used for defining position. In each system the location of the origin *O* and the direction of the reference axes can be arbitrarily chosen to yield the simplest relationships.

Displacement is a change in position. It is completely determined if two quantities are known—the *magnitude* of the change in position and the *direction* in which the change takes place, *Figs.* 3 and 4. The symbol Δ (Greek delta) in *Fig.* 4 may

Fig. 1—Rectilinear co-ordinates. The position of point *A* relative to the origin of the co-ordinate system, *O*, is positively known if the co-ordinate distances *x* and *y* are known

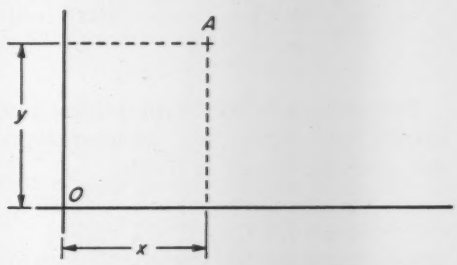
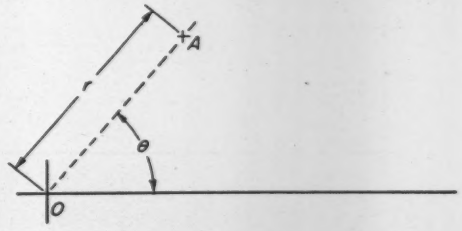


Fig. 2—Polar co-ordinates. The position of point *A* is positively established if the quantities *r* and *θ* are known



be likened to a coefficient which merely indicates that quantities denoted by Δx, Δy, etc., are changes in the values of x, y, etc.

Quantities such as linear displacement which require a direction as well as a magnitude for complete definition are known as *vector* quantities. Quantities such as mass which are completely defined when their magnitudes are known are *scalar* quantities. All vector quantities which occur in motion studies, with the exception of angular displacement of a body, obey the rule of addition shown in *Fig.* 5.

Velocity of a point is the rate of change of its position. Referring to *Fig.* 3, a point was originally at A when the time was t_a. At some later time t_b the point had moved to position B. The average velocity during the interval t_a to t_b is the displacement in that interval divided by the time required for the displacement:

$$V_{(av)} = \frac{s}{t_b - t_a} \quad \ldots\ldots (1)$$

The average velocities in the co-ordinate directions x and y, *Fig.* 4, are similarly given by the relationships:

$$V_{x(av)} = \frac{x_b - x_a}{t_b - t_a} = \frac{\Delta x}{\Delta t} \quad \ldots\ldots (2)$$

$$V_{y(av)} = \frac{y_b - y_a}{t_b - t_a} = \frac{\Delta y}{\Delta t} \quad \ldots\ldots (3)$$

To obtain the velocity at a given point rather than the average velocity over a finite time interval, the time interval must be made very small. The following type of equation is a short-hand expression for "V_x is the limiting value of $\Delta x/\Delta t$ when Δt approaches zero."

$$V_x = \text{Lim}\ \frac{\Delta x}{\Delta t}\Big]_{\Delta t \to 0} \quad \ldots\ldots (4)$$

$$V_y = \text{Lim}\ \frac{\Delta y}{\Delta t}\Big]_{\Delta t \to 0} \quad \ldots\ldots (5)$$

Velocities are vector quantities having both magnitude and direction. Displacement and velocity are concepts familiar to all.

Acceleration of a point is the rate of change of its velocity. A point at time t_a is located at position A and has velocity V_a, *Fig. 7a.* At time t_b the point is located at position B and has velocity V_b. The change of velocity is $V_b - V_a$, so the average acceleration in the interval $t_b - t_a$ is given by:

$$a_{(av)} = \frac{V_b - V_a}{t_b - t_a} = \frac{\Delta V}{\Delta t} \quad \ldots\ldots (6)$$

The numerator of Equation 6 is a vector and its value is shown graphically in *Fig. 7b.* The acceleration has a magnitude equal to the vector ΔV divided by the time interval Δt and is in the direction of ΔV. To obtain the acceleration at point A the time interval is made smaller and smaller as indicated by

$$a = \text{Lim}\ \frac{\Delta V}{\Delta t}\Big]_{\Delta t \to 0} \quad \ldots\ldots (7)$$

Our physical concept of acceleration is apt to be less clear than our concepts of displacement and velocity, but in the starting and stopping of elevators, automobiles, aircraft and trains we have experienced rapid changes in velocity. We are familiar with the rate at which falling objects change their velocity. The acceleration of gravity, 32.2 feet per second per second, commonly designated by the letter g, is often used as a unit of acceleration. For example, an airplane structure may be designed to withstand a $10g$ acceleration—an acceleration ten times as great as that to which a freely falling body is subjected.

A *rigid body* is defined as a collection of matter within prescribed boundaries, any point or particle of which always remains at the same distance from all other points or particles of the body. All real bodies such as machine parts actually undergo changes in dimension and shape when subjected to external loads, but such deformations are very small relative to the motion of the body. Except in certain vibration problems where internal velocities, and the accelerations resulting from them, are extremely important such deformations can be considered negligible relative to the motion of the body, and are so considered in this article.

Two observations derive directly from the definition of the rigid body:

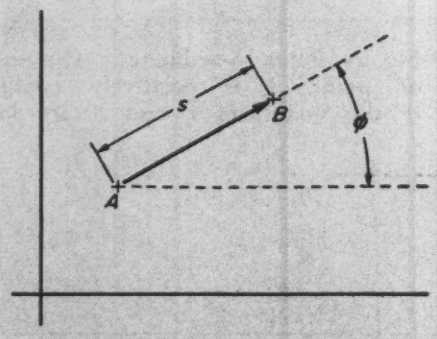


Fig. 3 — Left — Displacement. If a point moves from A to B the magnitude of displacement is s and the direction is ϕ

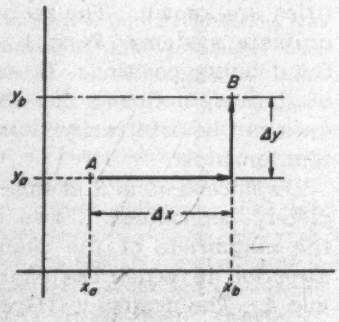


Fig. 4 — Right — Displacement. If a point moves from A to B the displacement can be represented by the component rectilinear displacements Δx and Δy

1. The relative velocity of one point on a rigid body to a second point on the body along the straight line connecting the two points must be zero. Otherwise the distance between the two points would change, *Fig.* 8.
2. The relative velocity of one point on a rigid body to a second point on the body is in a direction perpendicular to the straight line joining the two points and is equal to the product of the distance between the points and the angular velocity of the rigid body.

In the remainder of this article the foregoing important concepts and definitions are applied to the solution of some important motion problems.

Fig. 5—Vector addition. The sum of two vectors is found by drawing the vector lines in series and in their proper directions. Vector sum is the line drawn from the tail of the first vector to the tip of the last: $A + B = C$

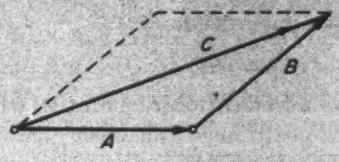


Fig. 6—Vector subtraction. The difference of two vectors is found by drawing the vector lines in series but with the subtracted vector in opposite direction: $A - B = D$

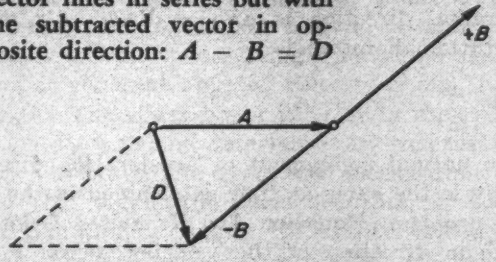
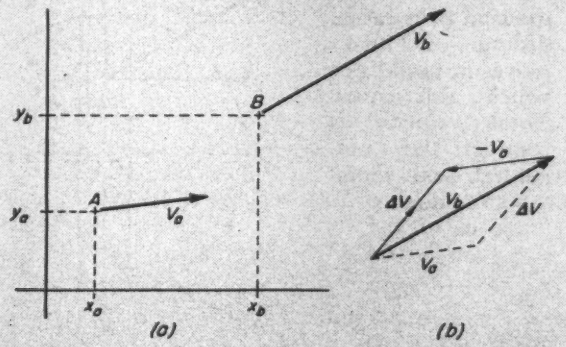


Fig. 7—Velocity change. Subtraction of velocity at *A* from that at *B* is illustrated at (*b*); method follows the rule given in *Fig.* 6



MECHANISM ANALYSIS

Rotation About a Fixed Axis: When a disk is constrained to rotate about a fixed axis *O*, *Fig.* 9*a*, its position at a particular time is denoted by the angle θ_1 between a radial line *OA* and a reference line *CC*. If a change in angular displacement of the disk occurs, it will assume a new position such as that indicated by θ_2. The angular velocity of the disk, ω, is defined as the limit of the change in displacement divided by the time interval in which the change of displacement occurs as the time interval approaches zero:

$$\omega = \text{Lim}\ \frac{\Delta\theta}{\Delta t}\Big]_{\Delta t \to 0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

The change in angular displacement is given by $\Delta\theta = \theta_2 - \theta_1$, *Fig.* 9*a*.

If the angular speed of the disk is changing, after an interval of time has elapsed the angular velocity of the disk will change from a value ω_1 to a new value ω_2. The difference between these two angular velocities is the change in angular velocity occurring over the time interval, Δt, or $\omega_2 - \omega_1 = \Delta\omega$. *Angular acceleration*, of the disk is defined as

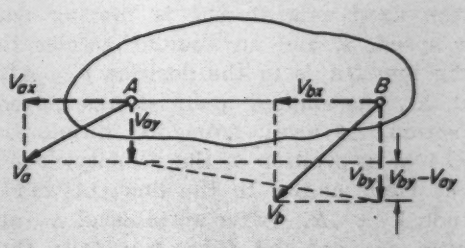
$$\alpha = \text{Lim}\ \frac{\Delta\omega}{\Delta t}\Big]_{\Delta t \to 0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

In the time interval, Δt, during which the body has changed its position from that indicated by θ_1 to that indicated by θ_2, the *average* angular velocity is $(\omega + \frac{1}{2}\Delta\omega)$. The corresponding angular displacement $\Delta\theta$, for small values of Δt, therefore is:

$$\Delta\theta = (\omega + \tfrac{1}{2}\,\Delta\omega)\,\Delta t$$
$$= \omega\Delta t + \tfrac{1}{2}\,\Delta\omega\Delta t$$
$$\Delta\theta = \omega\Delta t + \tfrac{1}{2}\alpha\Delta t^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Acceleration in Rotation: The disk in *Fig.* 9*a* is rotating about the fixed axis *O* with a constant

Fig. 8—Rigid body concepts. Component of point *A*'s velocity long the line *AB* must be equal to and in the same direction as point *B*'s component of velocity along *AB*. Difference between components of *A*'s and *B*'s velocities perpendicular to the line *AB* is equal to the distance *AB* times the angular velocity of the body



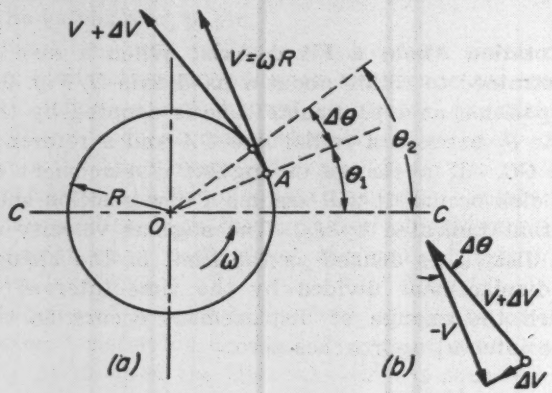


Fig. 9—Rotation at constant angular velocity. Change in linear velocity of point A is due entirely to change of direction due to rotation

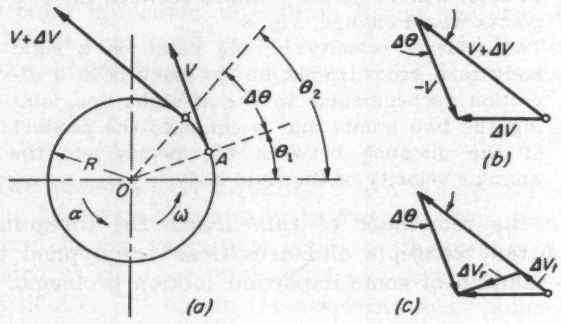


Fig. 10—Rotation with angular acceleration. Vector diagram for determining total velocity change is shown at *b*. Radial and tangential components are indicated at *c*

angular speed, ω. What are the velocity and acceleration of point A in the position shown? The velocity of point A is $V = \omega R$. After a time Δt, the line OA will move to a new position, $\Delta\theta$ away from its original position. A's velocity will have changed from V to $(V + \Delta V)$. Because the angular velocity ω is constant, the absolute value of the velocity vectors V and $(V + \Delta V)$ will be the same, but they will be in different directions. The vector velocity plot, *Fig.* 9*b*, indicates this situation. The difference in A's velocity in moving from its initial position to one which it occupies, a time interval Δt later, is shown as ΔV. From the geometry of *Fig.* 9*b* the value of ΔV is computed as $\Delta V = V(\Delta\theta)$. Dividing the change in velocity ΔV by the time interval Δt in which the change occurs gives the average acceleration of point A over the interval Δt:

$$a = \frac{\Delta V}{\Delta t} = V\frac{\Delta\theta}{\Delta t} = V\omega = \omega^2 R \quad \ldots\ldots\ldots\ldots (11)$$

The smaller the time interval Δt, the nearer is the value of this average acceleration to the actual acceleration of point A at its initial position. Thus, the acceleration of point A is given by $\omega^2 R$ and is in a radial direction. It is important to note that this acceleration, often referred to as a centrifugal acceleration, is the result of a change in direction of a velocity vector whose magnitude remains constant.

In *Fig.* 10*a*, the same disk is shown rotating about the fixed axis O, but is moving with an angular speed, ω, and an angular acceleration, α, when the line OA is in the position θ_1. After an interval, Δt, has elapsed, point A has moved to a new position, $\Delta\theta$ away from its initial position. When OA is in position θ_1 the velocity of A is directed at right angles to the line OA and has a magnitude $V = \omega R$. After an interval Δt, angular velocity is $\omega + \alpha\Delta t$ and A has a velocity $V + \Delta V$ directed at right angles to the new position of the line OA with a magnitude

$$V + \Delta V = (\omega + \alpha\Delta t)R \quad \ldots\ldots\ldots\ldots (12)$$

To find the acceleration of point A when the line OA is in the position θ, the basic definition of acceleration, Equation 7, is used. The change in A's velocity during the time interval, Δt, is given by the vector ΔV, shown in *Fig.* 10*b*. This change in velocity can be broken up into two component changes, one in the radial direction, ΔV_r, and one in the tangential direction, ΔV_t, *Fig.* 10*c*. From the geometry of *Fig.* 10*c* the change in A's velocity in a radial direction is $\Delta V_r = V\Delta\theta$. A's radial acceleration therefore is

$$a_r = V\frac{\Delta\theta}{\Delta t} = V\omega = \omega^2 R \quad \ldots\ldots\ldots\ldots (13)$$

This normal component of acceleration directed radially is the same as that determined in the previous problem, Equation 11. It arises from the change in direction of the velocity vector V. In addition the existence of an angular acceleration has also produced a change in the magnitude of the velocity vector of point A during the time in-

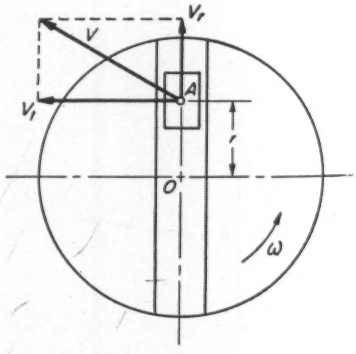


Fig. 11—Effect of rotation plus radial sliding. Slider moves in radial slot which also turns. Total velocity is resultant of tangential and radial components

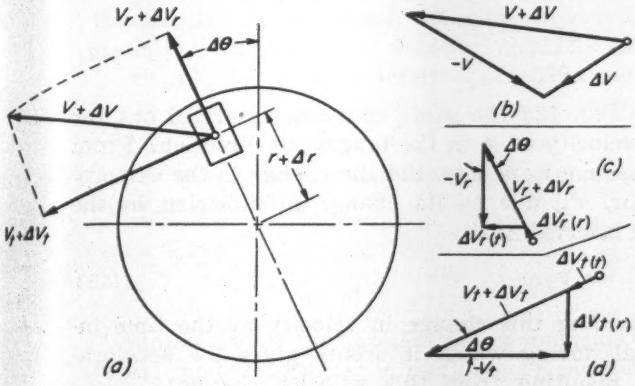


Fig. 12—Velocity picture of *Fig.* 11 after slight rotation. Total velocity change ΔV from *Fig.* 11 to *Fig.* 12 is shown at *b*. Change in radial component is shown at *c* and in tangential component at *d*

terval, Δt, to a new value $V + \Delta V$. This change in magnitude appears as the vector, ΔV_t. As the time interval, Δt, and the displacement angle, $\Delta\theta$, approach very small values, the direction of this component becomes 90 degrees to the radius. The acceleration component in the tangential direction is found by dividing this velocity vector, ΔV_t, by the time interval Δt:

$$a_t = \frac{\Delta V_t}{\Delta t} = \frac{(\omega + \Delta\omega)R - \omega R}{\Delta t} = R\frac{\Delta\omega}{\Delta t} = R\alpha \quad (14)$$

Acceleration in the Presence of Sliding: The system shown in *Fig.* 11 has a slider *A* which moves along a slot in the rotating disk while the latter turns at constant angular velocity about the fixed axis *O*. The slider has a velocity in the radial direction V_r which is determined by external conditions. What is the resultant acceleration of the point *A*? Again the basic definition of acceleration, Equation 7, is used. The radial velocity of *A*, V_r, in this position is already given. V_t, the component of *A*'s velocity in the tangential direction, is equal to the angular velocity times the radius *r*. The resultant velocity is shown in *Fig.* 11 as *V*.

If the disk now moves to a new position where the slot makes an angle, $\Delta\theta$, with its original position, $\Delta\theta$ being a small angle (of the order of magnitude of 1/10 of a radian perhaps), the new velocity picture is as shown in *Fig.* 12*a*. The radial velocity V_r has changed both in magnitude and direction. The tangential component of *A*'s velocity is now given by $\omega\ (r + \Delta r)$, since the slide has moved to a new radial position. Again the resultant velocity of *A* is shown in *Fig.* 12*a* as the resultant of the two components $(V_r + \Delta V_r)$ and $(V_t + \Delta V_t)$. In *Fig.* 12*b*, the vector difference between these two resultant velocities is obtained. This vector difference divided by the time interval during which the velocity change occurred then becomes the acceleration of point *A*. It is average acceleration over the interval Δt. As Δt is selected to be small, $\Delta V/\Delta t$ approaches closely the actual value of *A*'s acceleration in the position shown in *Fig.* 11.

Although this answer is a complete one obtained with a minimum of effort, it is significant to know the acceleration components produced by changes in the magnitude and direction of the two component velocity vectors V_r and V_t. In *Fig.* 12*c* V_r is shown subtracted from $V_r + \Delta V_r$. The vector difference between these two velocities can be thought of in terms of a tangential component $\Delta V_{r(t)}$ and a radial component $\Delta V_{r(r)}$. From the geometry of *Fig.* 12*c* it is apparent that:

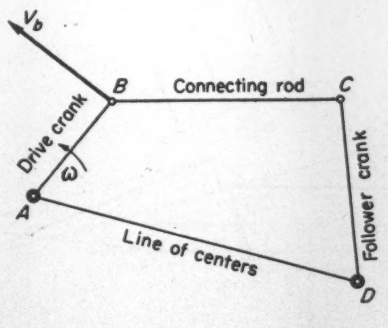
$$\Delta V_{r(t)} = V_r\,\Delta\theta \quad (15)$$

Dividing this velocity change by the time interval during which it occurred gives the acceleration component produced by this velocity change:

$$a_{t(r)} = V_r\frac{\Delta\theta}{\Delta t} = V_r\omega \quad (16)$$

Note that this acceleration produced by a change in direction of the velocity vector V_r is equal to the magnitude of that velocity times the angular velocity with which it is rotating. The radial component $\Delta V_{r(r)}$ divided by the time interval during which this change occurs yields the component of

Fig. 13—Four-bar linkage. Line of centers is fixed while drive crank rotates



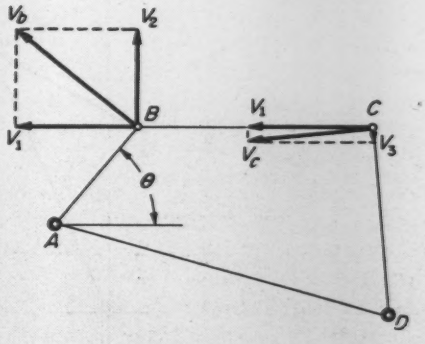
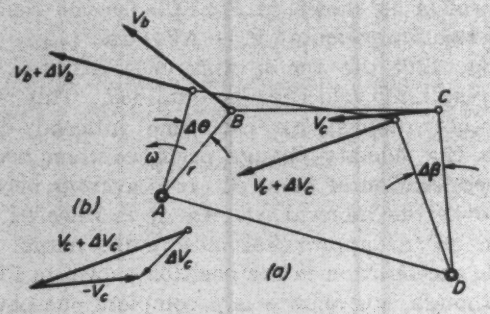


Fig. 14—Velocity analysis of four-bar linkage. Velocity V_c is perpendicular to *CD*, V_1 is along *BC*, V_2 and V_3 are perpendicular to *BC*

Fig. 15—Acceleration analysis of four-bar linkage. Velocity change between successive positions of the mechanism is determined at *b*. Time interval corresponding to $\Delta\theta$ establishes acceleration



acceleration in the radial direction resulting from changes in the velocity V_r and is given by

$$a_{r(r)} = \frac{\Delta V_r}{\Delta t} \quad \ldots\ldots (17)$$

In *Fig.* 12*d* the same analysis is carried out for the velocity of *A* in the tangential direction. From the geometry of *Fig.* 12*d* the change in the velocity vector, V_t, due to its change in direction in the time interval Δt is

$$\Delta V_{t(r)} = V_t \Delta\theta \quad \ldots\ldots (18)$$

Dividing this change in velocity by the time interval during which it occurs gives the acceleration resulting from this velocity change:

$$a_{r(t)} = V_t \frac{\Delta\theta}{\Delta t} = V_t\omega = \omega^2 r \quad \ldots\ldots (19)$$

Again it will be noted that this acceleration pro-

Fig. 16 — Linkage with sliding elements. Difference between V_a and V_b is the velocity with which block slides on link

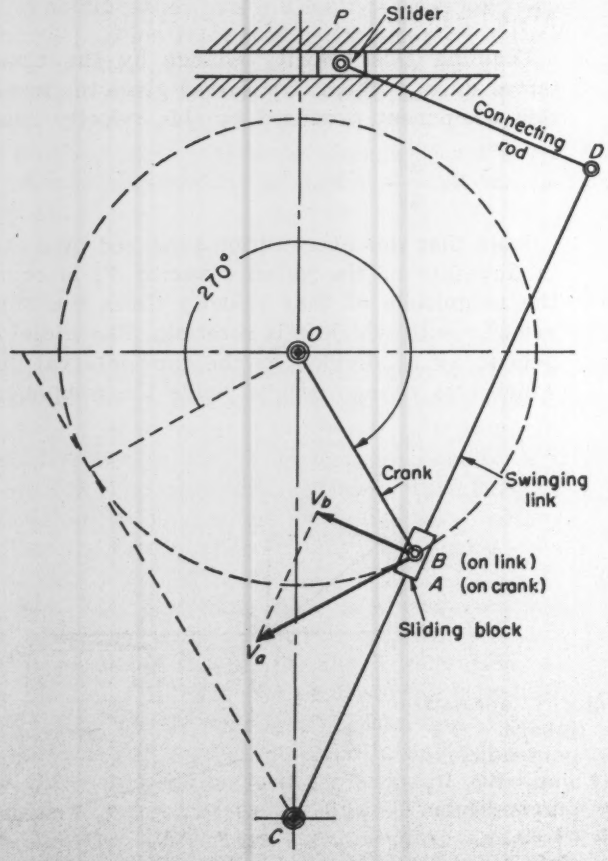
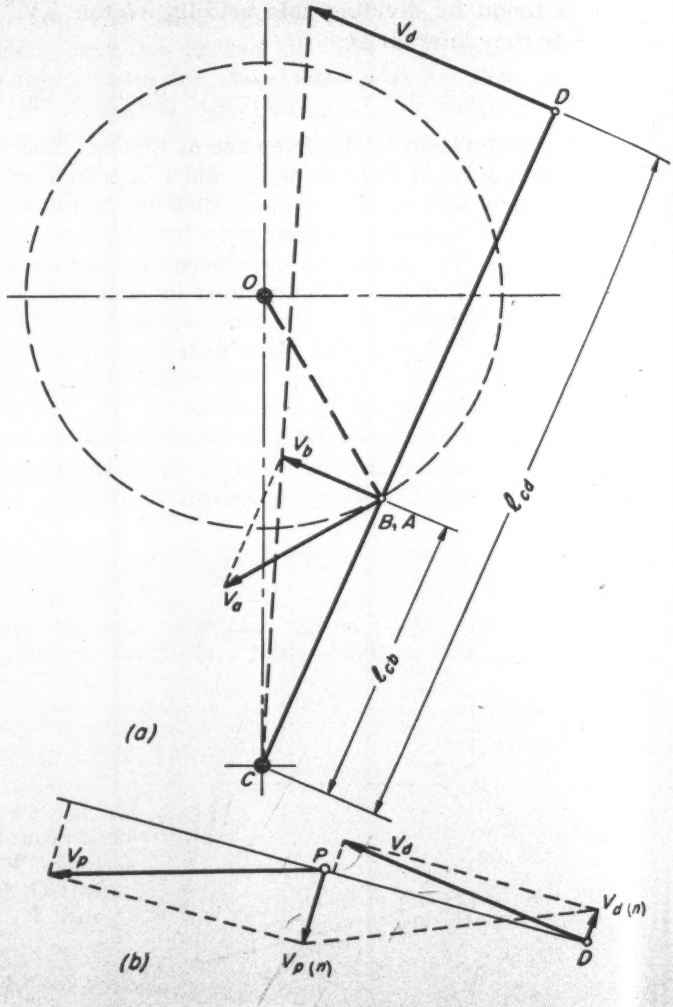


Fig. 17—(*a*) Swinging link portion of *Fig.* 16, showing graphical solution for velocity of point *D*. (*b*) Slider-connecting rod portion of *Fig.* 16, showing solution for velocity of slider *P*



duced by a change in direction of a velocity vector is given by the product of that velocity vector and its angular speed. Since the slide is moving out radially, the tangential velocity also has changed in magnitude, the time interval Δt. This change is

$$\Delta V_{t(t)} = \omega(r + \Delta r) - \omega r = \omega \Delta r \quad \ldots\ldots\ldots\ldots (20)$$

The acceleration component resulting from this velocity change is

$$a_{t(t)} = \frac{\Delta V_{t(t)}}{\Delta t} = \frac{\omega \Delta r}{\Delta t} = \omega V_r \quad \ldots\ldots\ldots\ldots (21)$$

Summation of the acceleration components in the radial and tangential directions (Equations 16, 17, 19 and 20) yields these results:

$$a_r = \frac{dV_r}{dt} - \omega^2 r \quad \ldots\ldots\ldots\ldots (22)$$

$$a_t = 2\omega V_r \quad \ldots\ldots\ldots\ldots (23)$$

The acceleration component a_t is often referred to as the Coriolis acceleration. These results are identical to the answer previously obtained in *Fig.* 12*b*. If ω is changing, Equation 23 becomes $a_t = 2\omega V_r + \alpha r$.

Four-bar Linkage: The four-bar linkage is an elemental mechanism of great actual and potential usefulness. Because of the difficulty experienced in handling the mathematical relationships which express the behavior of this mechanism, the job of determining the values of the basic parameters required to produce a desired result has limited its use. A recent book *Analysis of the Four-bar Linkage**, makes available considerable design information which should be of help to designers in utilizing more fully this versatile linkage. The basic concepts discussed in this article are useful in obtaining accelerations from the velocity information given in the book. In addition these concepts permit rapid analysis of linkages not treated in the book. The following discussion is an application of the few basic concepts previously introduced to the analysis of motion in the four-bar linkages.

PIN-JOINT LINKAGE: The four-bar linkage shown in *Fig.* 13 has fixed line of centers and a drive crank rotating at constant angular speed. It is desired to find the velocity and acceleration of point *C*, the pivot at the end of the follower crank.

The drive crank velocity V_b is laid out to scale, *Fig.* 14. The components of V_b along the connecting rod and at right angles to it are drawn. In view of the property of rigid body *BC* that there

*Hrones and Nelson—*Analysis of the Four-Bar Linkage*, John Wiley & Sons, Technology Press, 1951.

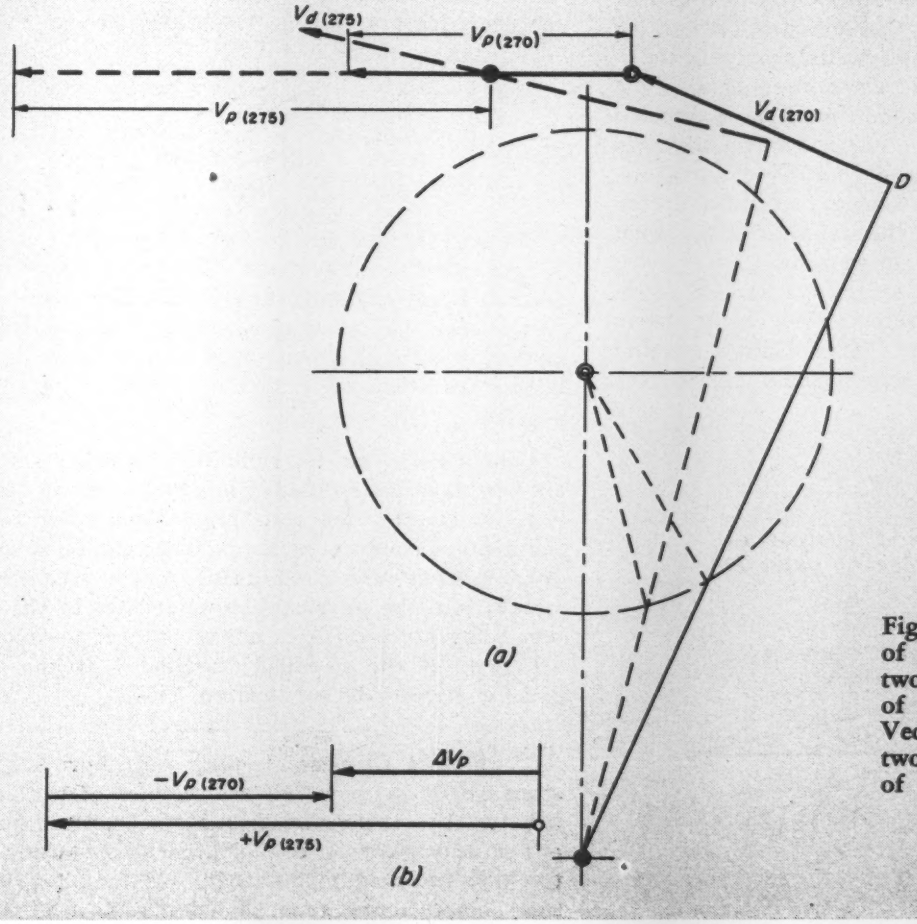


Fig. 18—(*a*) Velocities of point *D*, *Fig.* 16, in two successive positions of the mechanism. (*b*) Vector subtraction of two successive velocities of point *P* (compare with *Fig.* 6)

can be no velocity of point C relative to point B along the line joining the two points, V_1 is therefore also the component of the velocity of point C along line BC. In addition the crank CD is constrained to rotate about point D. Therefore, the direction of the velocity of point C must be perpendicular to the crank CD. The intercept of a line drawn at right angles to BC at the terminal of vector V_1 establishes the velocity V_c. The component V_3 is that part of V_c (on the connecting rod) which is due to rotation about a point on line BC, and must be at right angles to BC.

In order to find the acceleration of point C when the mechanism is in the position shown, it is necessary only to apply the basic definition of acceleration, Equation 7. To determine the value of the change in velocity ΔV_c draw the linkage in a new position, *Fig.* 15, in which the crank angle θ is greater by an amount $\Delta\theta$ than that shown in *Fig.* 14. The average acceleration of point C over the interval $\Delta\theta$ is the vector ΔV_c divided by the time interval Δt. The angular and time intervals are related by $\Delta\theta = \omega(\Delta t)$; therefore:

$$a_c = \frac{\Delta V_c}{\Delta t} = \frac{(\Delta V_c)\omega}{\Delta\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24)$$

Hence, both magnitude and direction of the acceleration have been determined. A convenient interval to use is 5 degrees although this may be varied depending on circumstances. As in *Fig.* 10*c*, the velocity change and the acceleration can be resolved into tangential and radial components.

LINKAGE WITH SLIDING: The foregoing example concerned a mechanism made up of pin-connected members. Analysis of accelerations in linkages where sliding exists is often considered more difficult. Application of the same principles to the following problem yields the solution with equal ease even though sliding is present.

A swinging-block quick-return mechanism is reproduced in *Fig.* 16 with the drive crank shown in its 270-degree position. It is desired to find the acceleration of the swinging link and of the slider. Lay out the velocity of point A cn the drive crank. Find the velocity of point B on the swinging link, recognizing that the component of velocity of both point A and point B in a direction normal to the direction of sliding must be the same. The velocities of D and of P may now be readily found, *Fig.* 17. Now redraw the mechanism with the drive crank in the 275-degree position, and repeat the velocity solution, *Fig.* 18*a*. The average acceleration of point P in the interval of drive crank angle 270 to 275 degrees is given by:

$$a_p = \frac{\Delta V_p}{\Delta t} = (\Delta V_p)\left(\frac{\omega_{oa}}{2\pi}\right)\left(\frac{360}{5}\right) \quad \ldots\ldots\ldots\ldots (25)$$

where ΔV_p is determined as shown in *Fig.* 18*b*, $\Delta V_p = V_{p(275)} - V_{p(270)}$.

Angular Acceleration: From the previous analysis the velocities of point D when the drive crank is in the 270 and 275-degree positions are known. They are replotted in *Fig.* 19. The change in the velocity of point D in the 5-degree interval is (ΔV_d). The vectors are subtracted in *Fig.* 19 yielding (ΔV_d). The components of (ΔV_d) in the normal and tangential directions are also shown. The tangential component of the velocity change divided by the time interval and by the radius l_{cd} yields the desired angular acceleration.

$$\alpha_{cd} = \frac{(\Delta V_d)_t\,\omega_{oa}}{(l_{cd})\,(5/360)\,2\pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (26)$$

When the analysis is based on a value of ω_{oa} of one radian per unit time Equations 25 and 26 can be written:

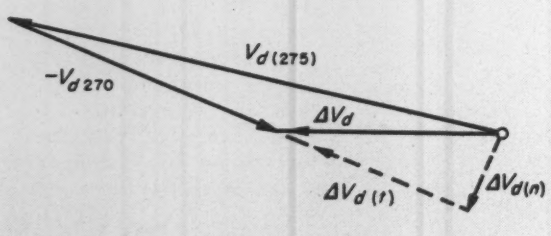
$$a_p = \Delta V_p\left(\frac{\omega_{oa}}{2\pi}\right)\left(\frac{360}{\Delta\theta}\right)$$

$$\alpha_{cd} = \Delta V_d\,\frac{\omega_{oa}^2}{2\pi}\left(\frac{360}{\Delta\theta}\right)$$

The attack used in the foregoing motion studies is applicable to all systems. Graphical means were used in these examples (they are often faster and less susceptible to major errors than analytical methods), though when exact values must be obtained analytical treatment of the same attack is possible.

Conclusion: The determination of velocities and accelerations can be readily handled by using directly a few simple basic concepts without reference to the many specialized methods and techniques which are in current use. Such an approach gives a clear insight into the physical characteristics of the system being studied. It is not as subject to error as are some of the so-called "methods". It has complete generality of application.

Fig. 19—Graphical analysis of the velocity change of point *D*



"I am sure that maintaining and improving the standard of living of all the peoples of the earth through the increasing use of mechanical horsepower and the scientific approach is now one of the keys to peace in the world."—CHARLES E. WILSON, *Secretary of defense*

Charts for STRESS VISUALIZATION

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Murray Hill, N. J.

IN stress analysis, it is relatively easy to visualize how principal stresses vary from point to point in many common machine elements subjected to a variety of types of loading. However, it becomes more difficult to develop a mental picture of how stress varies with direction at a point. The usual design procedure is to study the stress distribution in a body, and then to locate the maximum normal and shear stresses. To serve as an aid in this process the stress visualization chart on the next two pages shows how stresses vary with direction in the plane of any two principal stresses, that is, in any principal plane through a point under examination. From these curves the designer can keep prominent normal (tensile and compressive) stresses well in mind and know where shear stresses tend to become relatively high.

At any point in a structural element of a machine there are always three mutually perpendicular planes upon which all shear stresses vanish. These planes are the principal planes at the point, and the normal stresses acting on the principal planes are termed the principal stresses at the point. It should be remembered that the principal stresses vary not only in magnitude, but also in direction from one point to another in a body.

The stress visualization chart shows ten different combinations of any two of the three principal stresses at a point, namely: s_1 and s_2. The different configurations in the chart depict the variation in normal and shear stresses with direction for various combinations of direction and relative magnitudes of s_1 and s_2.

Curves for each configuration in the stress visualization chart have been made by the following procedure. In *Fig.* 1 let any plane PL perpendicularly intersect the s_1s_2 principal plane through point O. A normal line N to plane PL at O will make an angle θ with the direction of s_1; angle θ may be measured in the clockwise or counterclockwise rotations. It follows then that the normal stress, s_n, on plane PL at angle θ is given by the equation

$$s_n = \frac{s_1 + s_2}{2} + \frac{s_1 - s_2}{2} \cos 2\theta \quad \ldots\ldots\ldots\ldots (1)$$

and the shear stress, s_s, on plane PL at angle θ can be shown to be

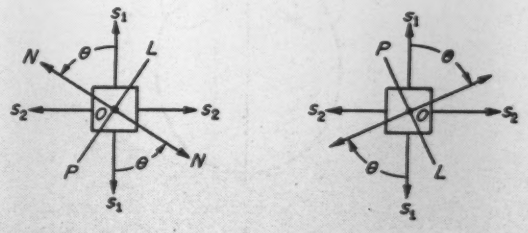
$$s_s = \frac{s_1 - s_2}{2} \sin 2\theta \quad \ldots\ldots\ldots\ldots (2)$$

From Equation 1 values of tensile stresses and compressive stresses have been plotted for various combinations of s_1 and s_2 for a series of values of θ as shown in *Figs.* 2 and 3. Similarly from Equation 2 curves for shear stresses have been plotted in *Figs.* 2 and 3.

From these charts several important points can be observed, namely:

1. When s_1 and s_2 are both either tensile or compressive and equal, no shear stresses appear on planes perpendicular to the s_1s_2 plane through the given examination point.
2. Maximum shear stress in the s_1s_2 plane always equals $\frac{1}{2}(s_1 - s_2)$.
3. Shear stresses reach a maximum at the point where $s_2 = -s_1$.
4. When s_1 and s_2 have the same signs, maximum shear stress in the s_1s_2 plane is equal to less than one-half the maximum normal stress.
5. When s_1 and s_2 have opposite signs, maximum shear stress in the s_1s_2 plane will be between 50 and 100 per cent of the maximum normal stress.
6. Maximum shear stress acting in the s_1s_2 plane is always directed at an angle of 45 degrees to the s_1 or s_2 axes.

Fig. 1—Basis for development of stress distribution curves



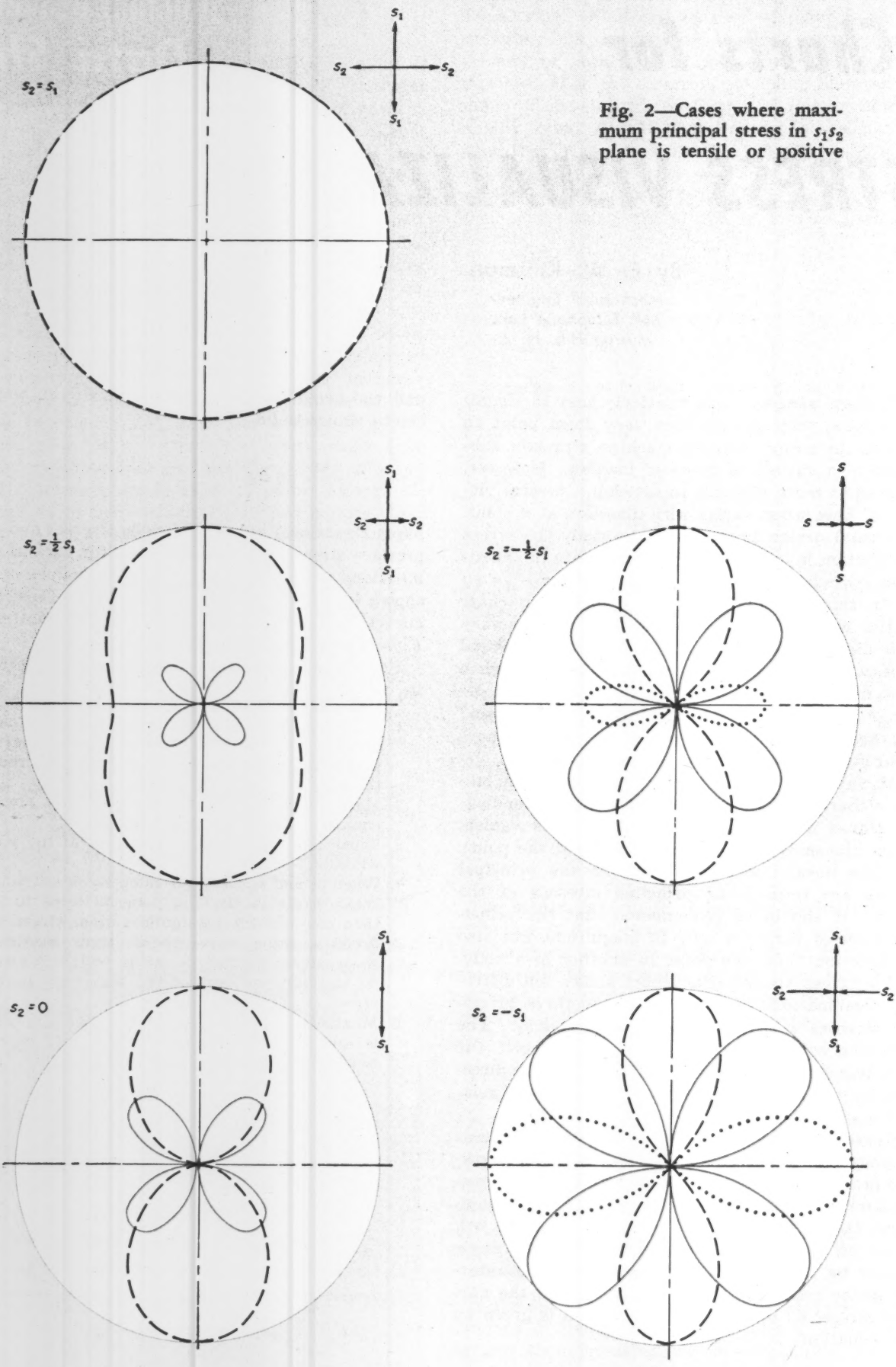


Fig. 2—Cases where maximum principal stress in $s_1 s_2$ plane is tensile or positive

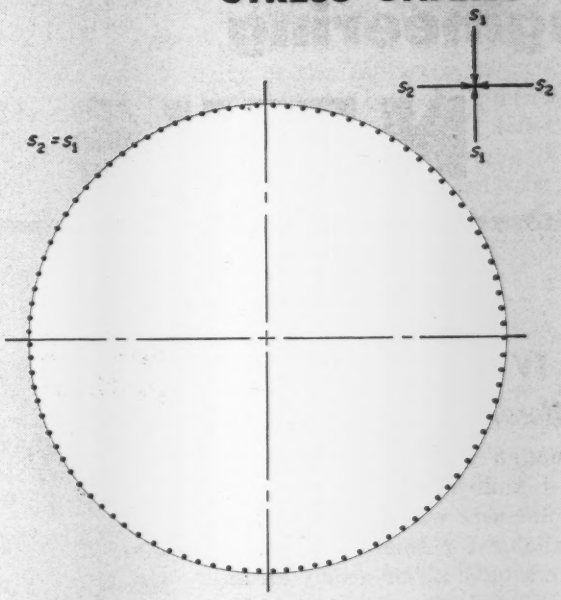


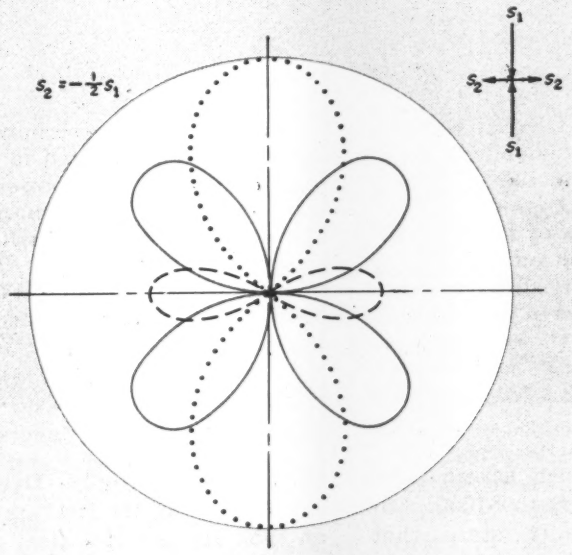
Fig. 3—Cases where maximum principal stress in s_1s_2 plane is compressive or negative

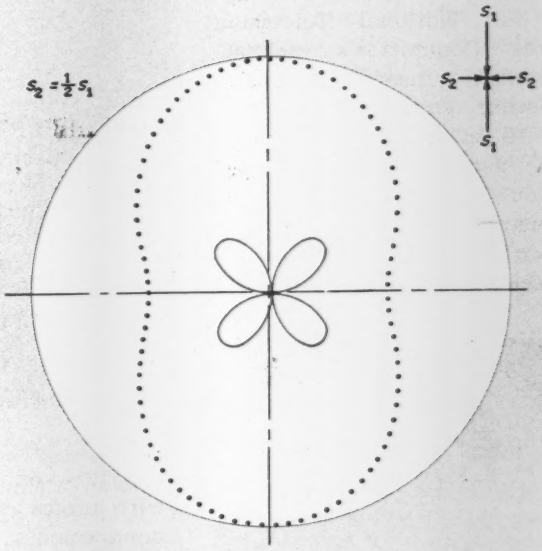
Key

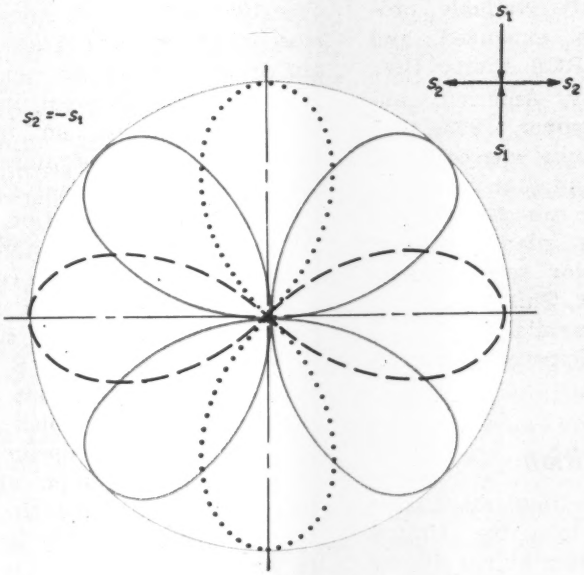
Tensile stress — — — — — —

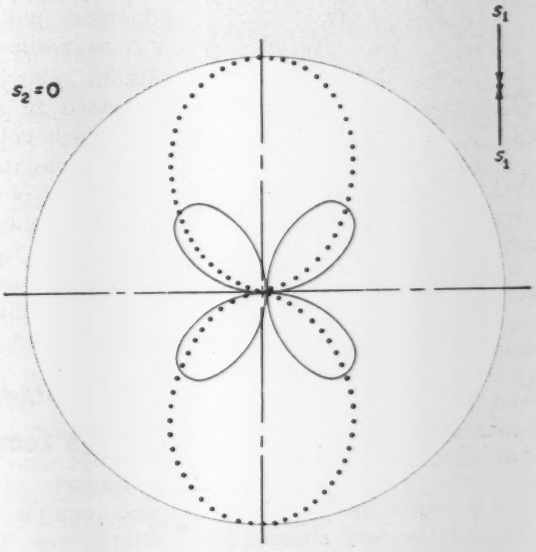
Compressive stress ••••••••••••••

Shear stress ——————————







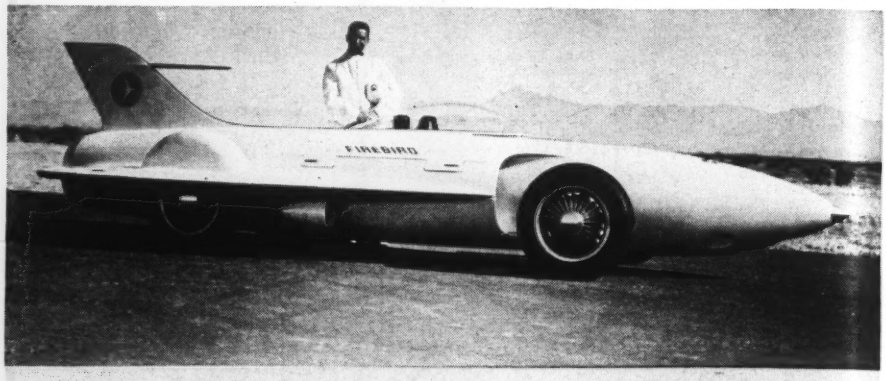


Engineering NEWS ROUNDUP

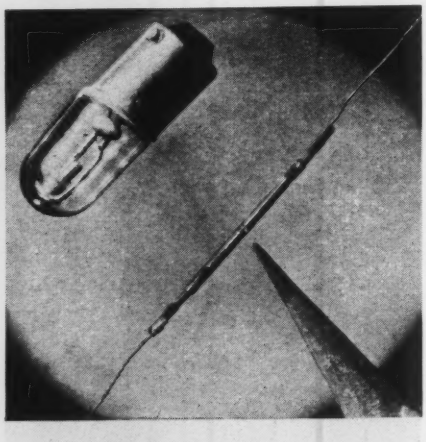
Color TV Is It Here?

Although authoritative opinions have it that small-screen, expensive color sets will not be generally available for some time, manufacturers have all or nearly all announced that they are producing color receivers since the FCC approved the National Television Standards Committee's compatible system. Insofar as color broadcasting equipment is concerned, 19 to 21 stations in the NBC-TV network were equipped for it on January 1, 1954, and more installations have undoubtedly been made in the meantime.

All receivers announced to date are 12½ or 14 inch screen sizes with prices of $800 to $1000. Announcements usually state that when tubes and other critical parts become sufficiently available, production will be expanded and prices reduced. RCA Victor Div., Radio Corp. of America, announced in December, 1953, that a 15-inch color tube was commercially available and that all black-and-white picture tube facilities at its Lancaster, Pa., plant had been converted to color tube production in November. This may make critical tubes available at an earlier than anticipated date.



FIREBIRD is General Motors' designation for their experimental gas-turbine automobile said to be the first built and tested in the U. S. Weight of the single-seat car is 2500 pounds. Horsepower of the Whirlfire engine is 370 at 13,000 rpm of the power turbine. Engine consists of two parts, a gasifier said to resemble a small jet engine and the turbine operating on the gasifier output to drive the rear wheels through a transmission. Fuel is kerosene. Wings and fin are said to give directional stability and provide air braking by flaps at rear of wings

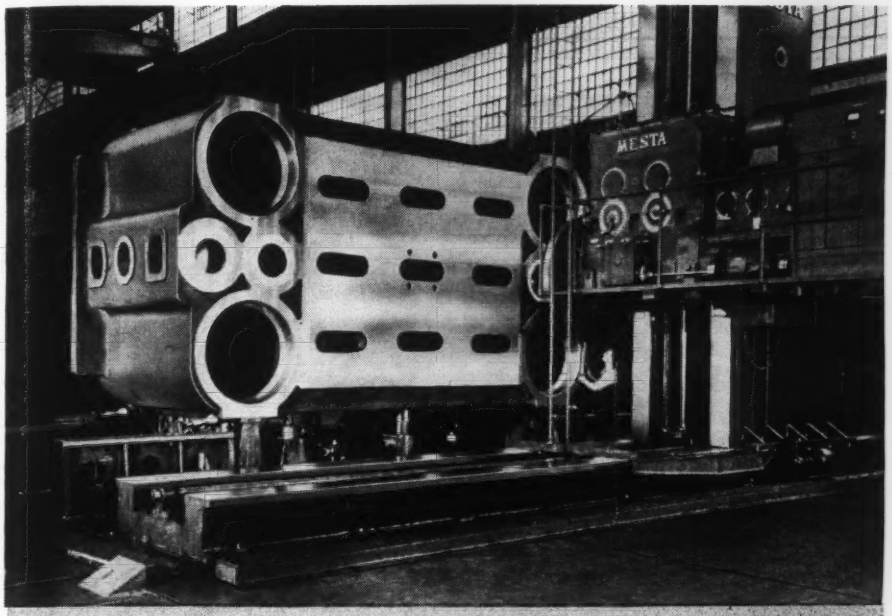


POINT SOURCE of light or nearly so is this contender for, or holder of, the title of the world's tiniest lamp. A sub-miniature neon-argon glow lamp 0.05-inch in diameter and 1¼ inches long, its glow is formed in a 0.04-inch gap between 0.03-inch electrodes. Power consumption is 1/30-watt. Fifty of the bulbs, side-by-side, are used to record events in laboratory experiments on moving film

NEMA Studies Foreign Competition

Imports of electrical machinery and equipment into the United States were 11 times higher during 1952 than before World War II. United States exports of the same products were only five times higher. During the first six months of 1953 foreign electrical sales in this country increased 50 per cent over 1952 while U. S. sales abroad rose only 9 per cent. These figures are from a 240-page report prepared by the National Industrial Conference Board, an impartial economic research organization retained by the National Electrical Manufacturers Association.

The previous figures tend to be even more startling when compared to the average figures for the years 1946-52. During that six-year postwar period, U. S. exports were 4.9 times higher than prewar; imports were 4.55 times greater. This increase in European production of electrical equipment during 1952 and 1953 seems to indicate that European industry is well on its way to recovery and is a competitor to be reckoned with in the world market.



BEHEMOTH BASE being machined here is one of two to be used in a 50,000-ton hydraulic die forging press being built by the Mesta Machine Co. Steel casting for the base section weighed 475,000 pounds. The completed press will be the largest ever built

Engineers . . . How to Attract and Hold Them

The average young engineer of 1954 is not looking for glamour. He wants security, both for today and for the years to come. He wants, above all else, to retain his professional standing, but he is more interested in a continuing and adequate pay check than he is in braving the pitfalls of the jungle or arctic frosts. He would rather plug along at a less romantic job with good chances of advancement than fight mosquitos to build a Panama Canal. In short, his aspirations are just about those of most other young men who have lived through the insecurity of a major depression, followed by a world upheaval the end of which is not yet in sight.

This attitude of the 1954 engineer is brought into sharp focus by the report on a nationwide survey just published in Washington by the Professional Engineers Conference Board for Industry, in cooperation with the National Society of Professional Engineers. The report, entitled *How to Attract and Hold Engineering Talent,* is the result of a survey in which 200 industrial employers of engineers and 1400 engineers employed in industry participated—a survey designed to provide management with a blueprint on how to create a climate in which engineers can work happily and effectively in an employee capacity.

It showed that 45 per cent of the engineers in industry are not satisfied today with the size of their pay checks; that 34 per cent of them do not feel that their prospects for advancement are good; that more than half of them do not know whether their employers are satisfied with their work; and that 38 per cent of them feel that their companies are not making effective use of their training and ability.

It showed, too, that approximately 40 per cent of all the engineers in industry are discontented with two or more important aspects of their jobs, a serious matter at a time when industry is clamoring for more and yet more engineers to fill jobs created by today's tremendous industrial expansion and by the ever-increasing technological complexity of manufacturing processes.

Although the report shows that the labor turnover among engineers in most industrial concerns is lower than the average for all employees, and although a majority of the engineers themselves indicated a typical reluctance to change jobs except under what they considered extreme provocation, the widespread discontent among so large a group of professional employees, coupled with a strong indication of a growing trend toward unionization, pointed to a danger which the professional cannot well ignore.

Of the 1400 engineers who responded to the questionnaire, 34 per cent said they felt they would benefit by membership in a collective bargaining organization—a significant increase since a similar survey was made five years ago, when the comparable figure was a mere 5 per cent.

An even greater number (66 per cent) said they believed their interests would be strengthened by membership in a nonbargaining organization, although many of the respondents pointed out that such an organization frequently is the first step toward outright unionization.

The results of the survey, according to the report, give clear warning to industry and to the professional societies that steps must be taken, and taken quickly, if the engineer's hard-won public recognition as a professional is to be maintained, and indeed, if the profession is to be saved from a descent to mediocrity and eventual classification as a trade.

The report, however, not only emphasizes the problem, but also points to some possible solutions to methods of achieving a greater harmony and community of purpose between the engineer and his employer, and of strengthening the former's attitudes of professionalism.

The Executive Research Survey reports are available from the Professional Engineers Conference Board for Industry, 1121 Fifteenth St., N.W., Washington 5, D. C. at $2.00 per copy to nonmembers and $1.00 per copy to members.

Briggs Mfg. Co. has been purchased by the Chrysler Corp. for $35 million. Briggs produced bodies for Chrysler Corp.'s Plymouth cars.

Twelve plants including ten in the Detroit area, one at Youngstown, O. and one at Evansville, Ind. with floor space in excess of 6 million square feet are covered by the purchase. Additional amounts will be paid for inventories on hand at the time of purchase.

The newly acquired facilities will be known as the Automotive Body Div. of Chrysler Corp. Automotive customers of Briggs which include Hudson and Packard will be served by the new division.

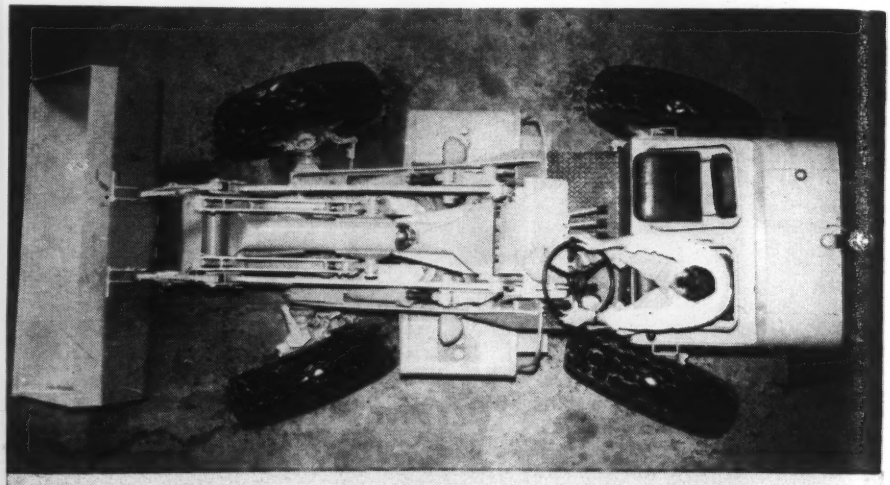
Curves May Cure Engineer Shortage

An assistant professor of mechanical engineering at Illinois Institute of Technology recently told the group at an Alumni luncheon that women engineers could help to alleviate the engineer shortage and implied that an effort to interest more young women in engineering careers would be well worth while. The professor's talk was titled "Engineers Can Wear Petticoats;" the professor's name is Mrs. Lois G. McDowell. She has studied at Rensselaer Polytechnic Institute and was the first woman to receive a master's degree in mechanical engineering from Illinois Tech.

Mrs. McDowell pointed out that more emphasis is being placed on "brain" work than physical labor by today's engineers and that, because of this, the well trained woman should be under no handicap in the engineering field. Various successful women engineers, Dr. Lillian Gilbreth, for example, were mentioned in the talk as further proof of the ability of women to succeed in the engineering field.

Engineering Principles Can Solve Social Problems

Calling on the nation's engineers to play a greater role in public life and to take the lead in "applying engineering principles to our social problems," Gwilym A. Price, president, Westinghouse Corp., recently addressed the annual dinner meeting of the ASME.



FOUR-WHEEL STEERING gets this vehicle around corners in a hurry. Called a Shoveloader by its makers, the Baker-Lull Corp., it has an inside turning radius of 7 feet 6 inches; 15 feet is typical for most automobiles. Four-wheel drive and high flotation tires permit operation of the loader in mud, snow and sand

"Because he is everywhere respected for his character, competence and record and is welcomed by all groups, the engineer might successfully erect a bridge between the technical and humanistic world, and bring diverse groups together into a common program as no one else is equally capable of doing." declared Mr. Price.

The first ASME-George Westinghouse Gold Medal Award was presented at the meeting to Alexander G. Christie, professor emeritus of mechanical engineering, Johns-Hopkins University. Honorary membership, highest award of the ASME, was presented to A. C. Monteith, vice president in charge of engineering for Westinghouse.

The Allis-Chalmers Mfg. Co. recently assumed operation of the Buda Co. Operating as a division of Allis-Chalmers, the Buda Co. will continue to manufacture, distribute and service all items in its regular line of products. At the present time the Buda Co. is building 22 models of fork lift trucks, seven models of towing tractors, 23 sizes of diesel engines and 20 sizes of natural gas, butane and gasoline engines, ranging from five to 516 horsepower. Ralph K. Mangan, president of Buda Co. since 1950, will be in charge of the new division with the title of president and general manager.

Industry Aided By Creative Mechanical Design

Possibilities for creative mechanical design, a new departure in engineering thought, were considered from the education and industry standpoints at the annual meeting of the ASME.

Challenging the old idea that ingenuity is an inborn quality and only the genius can create, Professor George B. DuBois, Department of Machine Design, Cornell University, stated that ingenuity can be taught. Based on five years' experience with a new course at Cornell, one-third of which takes the creative approach against two-thirds fundamental design methods, Professor DuBois claims "most problems do not require genius—just a little actual work with a pencil."

Application of this training is carried on to industry where the realization is growing that more time, and more thorough work on

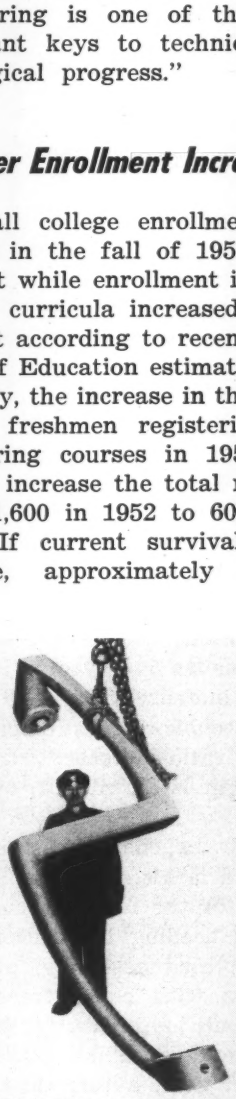
design development can reduce the number and cost of changes required later.

Industrial outlook was brought out by Maurice Nelles of Borg-Warner Central Research Laboratory, who stated "Creativeness in engineering is one of the most important keys to technical and sociological progress."

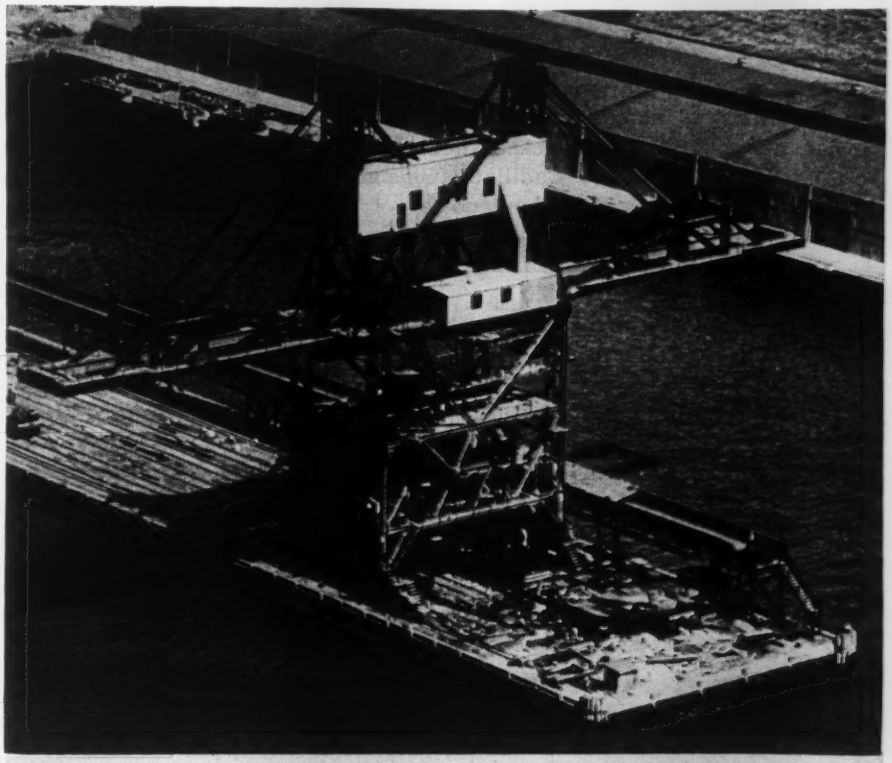
Engineer Enrollment Increases

Overall college enrollments increased in the fall of 1953 by 7 per cent while enrollment in engineering curricula increased by 18 per cent according to recent U. S. Office of Education estimates. Numerically, the increase in the number of freshmen registering for engineering courses in 1953 was 8600 to increase the total number from 51,600 in 1952 to 60,200 in 1953. If current survival rates continue, approximately 30,000 will graduate from accredited engineering curricula in 1957.

An even more interesting comparison can be made with enrollments in 1950 when engineering freshmen were only 6.6 per cent of total enrollment opposed to 10.5 per cent in 1953. This is a 59 per cent increase over the four-year period.



SIGMA BLADE: Large stainless steel casting is used for mixing plastics and is known as a "sigma blade" because of its shape. Pouring the blade presented a problem to Cooper Alloy Foundry Co. because a 1½ inch diameter hole is required throughout the 12 foot lineal length of the casting. Solution? A pipe of the same alloy as the casting, bent to proper shape and water cooled during casting to prevent melting



FASTEST SHIP UNLOADER on the Atlantic Coast is this tower recently installed at Baltimore. Capable of digging 1900 tons of ore per hour from ships or barges on either side of the Canton Railroad pier, the unloader may discharge into waiting freight cars or onto a conveyor belt. Designed, fabricated and erected by Heyl & Patternson Inc., the tower can travel the length of the 1250-ft pier

Obsolete Machines Cut Profit

Twenty-eight per cent of industry's production equipment and manufacturing processes are inadequate or obsolete according to a recent ASTE survey. Citing this survey, S. D. Maddock, president C.I.T. Corp. (the nation's largest industrial financing firm) indicated that "thousands of firms are losing much of their potential income because equipment which has outlived its usefulness is nibbling away at profits with slow production and excessive maintenance costs. Manufacturers must use modern machinery if they are to stay competitive."

Results of the ASTE survey are surprising because industrial financing has solved the problem of purchasing without weakening working capital. "The ideal arrangement," said Mr. Maddock, "is to fund the purchase price of the needed equipment over such a period that the equipment can begin to pay for itself out of increased earning capacity."

Harold W. Sweatt, president of Minneapolis-Honeywell Regulator Co. has been elected chairman of the board, succeeding Mark C. Honeywell who was named honorary chairman. Paul B. Wishart, has been elected president.

Rounding Up the 1954 Automobiles

(Continued from January)

Last month a trend to overhead-valve V-8 engines was noted. Since then three more auto manufacturers have released news of their 1954 models. All three—Cadillac, Oldsmobile and Ford—have increased horsepower of their engines with Ford announcing a new overhead-valve V-8 engine. The table here shows this trend.

Trends in Engine Types

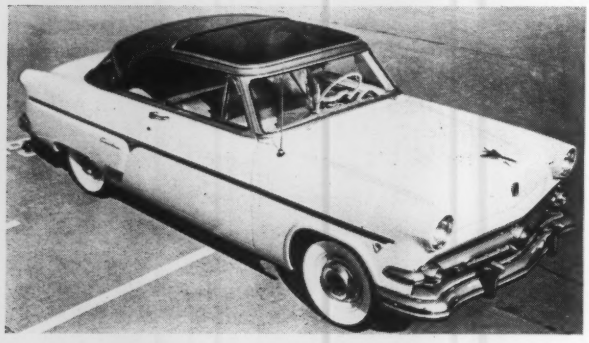
	1950		1953		1954	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
L-head, in-line 6	12	42.9	12	41.5	12	40.0
L-head, in-line 8	6	21.4	3	10.3	4	13.3
L-head, V-8	3	10.7	2	6.9	0	00.0
OHV, in-line 6	2	7.1	3	10.3	3	10.0
OHV, in-line 8	3	10.7	1	3.4	0	00.0
OHV, V8	2	7.1	8	27.6	11	36.7

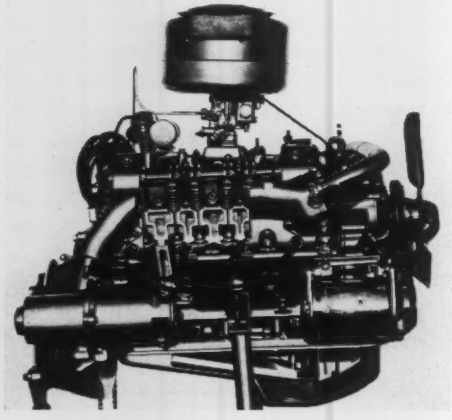
For comparison purposes, only engines used in cars having announced 1954 models were used in compilation of the table, and engines produced by the same manufacturer of identical basic design and displacement were considered as being one engine though horsepower might vary due to modifications such as high-compression heads, dual exhausts and four-barrel carburetors.

Although horsepower has increased rapidly it is interesting to note that the increase is the result of better design, not bigger engines. As an example of this, Chrysler's 1954 engine, rated at 235 hp, has a displacement only 7.5 cubic inches larger than the 1950 engine rated at 135 horsepower. Overhead valves, higher compression ratios, improved fuel induction systems and improved exhaust systems seem to be responsible for much of the increase in power; however, in all fairness it must be pointed out that certain L-head eights and sixes are as powerful as overhead-valve V-eights of equal displacement.

Only automobiles not included in either January or February are products of Kaiser-Willys Corp. These will be described as soon as 1954 models are announced.

FORD





NEW engines, a new body style and new front suspension are major differences between 1953 and 1954 Fords. Both six and eight-cylinder engines are available. The six is essentially the same as last year's Economy Run winner; however, a bore increase from 3.56 to 3.62 inches results in eight more cubic inches displacement which, added to a compression ratio increase, produces 14 additional horsepower. The eight is an all-new, overhead-valve, V-type.

Ford's new ball-joint front suspension was first used by Lincoln on 1952 models and is also used on the 1954 Mercury. Obvious advantages of the new suspension are reduction in number of points needing lubrication, fewer front suspension parts resulting in simplified assembly, and more space between front-suspension members with equal tread width. Easier riding and steering result from ball-joint construction.

A complete line of optional equipment, including power steering, power brakes, power windows, power seat, automatic transmission and overdrive transmission, is available. Twenty-three new upholstery patterns, 156 exterior and interior color combinations and 13 single-tone body colors will result in extremely colorful automobiles. Upholstering materials include vinyls, extruded plastics and new synthetic fabrics.

Crestline Skyliner is Ford's designation for their "hardtop" with transparent molded plastic sheet replacing the steel roof sheet above the driver's compartment. Blue-green tinting is said to block 60 per cent of the sun's heat rays and 72 per cent of the glare. A similar panel is available on convertibles. Shades are available to snap into place on the inside of the car if heat becomes excessive. Body changes are minor. A new rub rail, grille bar and stone shield treatment are most obvious. Tail-light lenses have also been restyled.

Size

Wheelbase (in.)	115.5
Length (in.)	198
Width (in.)	74.2
Height (in.)	62.3*

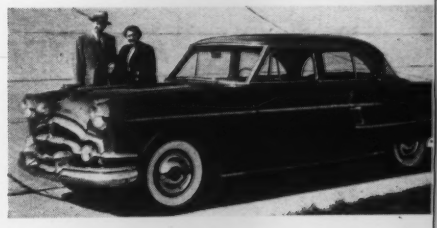
*Sedans

Ford
Engine Specifications

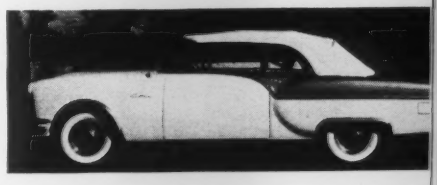
	Eight	Six
Type	OHV, Vee	OHV, in-line
No. Cyls.	8	6
Bore & stroke (in.)	3.50 x 3.10	3.62 x 3.60
Displ. (in.^{3})	239	223
Comp. ratio	7.2 to 1	7.2 to 1
Bhp, max.	130 @ 4200 rpm	115 @ 3900 rpm
Torque, max (lb-ft)	214 @ 1800-2200 rpm	193 @ 1000-2200 rpm

Ford's new V-8 engine is called a Y-block because of deep crankcase which extends well below the main-bearing parting line. Deep block has greater rigidity and provides a flat surface for oil pan attachment. Although compression ratio and displacement are the same as the 1953 L-head V-8, horsepower is 130, an increase of 20 horsepower over last year's 110 horsepower engine.

PACKARD



ONE of the largest, if not the largest, engines in the industry insofar as actual size and piston displacement are concerned is introduced in the 1954 Packards. This new L-head, in-line eight has a piston displacement of 359 cubic inches which, when teamed with a compression ratio of 8.7 to 1 and four-barrel carburetor, produces 212 horsepower at 4000 rpm. Greater passing ability at speeds of 40 to 70 miles per hour than any engine previously built by Packard is said to be delivered by this engine. The engine is used in all Packards except the Cavalier four-door sedan. Engines in all Clippers except the Special series also boast increased horsepower.



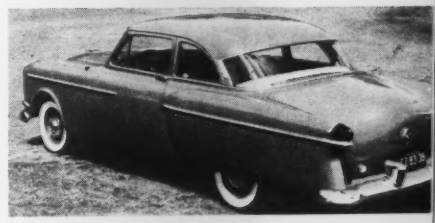
Styling changes in the Packard line are few; however, the Clippers have

Engine Specifications

	Clipper Special	Clipper Deluxe and Super	Cavalier	Patrician, Caribbean, etc.
Type	L-head, in-line	L-head, in-line	L-head, in-line	L-head, in-line
No. cyls.	8	8	8	8
Bore & Stroke (in.)	3½ x 3¾	3½ x 4¼	3½ x 4¼	$3\frac{9}{16}$ x 4½
Displ. (in.³)	288	327	327	359
Comp. ratio	7.70 to 1	8 to 1	8.0 to 1	8.7 to 1
Bhp, max	150 @ 4000 rpm	165 @ 3600 rpm	185 @ 4000 rpm	212 @ 4000 rpm

Size

	Clippers	Cavalier, Patrician	Caribbean, Pacific, Convertible	Limousine, Executive Sedan
Wheelbase (in.)	122	127	122	149
Overall length (in.)	$215\frac{13}{16}$	$216\frac{15}{16}$	$220\frac{9}{16}$	$238\frac{15}{16}$
Overall width (in.)	77⅞	77⅞	77⅞	77⅞
Overall height (in.)	$62\frac{11}{16}$	62⅞	62	63



many styling changes including higher, longer rear fenders with newly designed tail lights. Many new upholstery materials and colors have been introduced. Materials used include nylon, broadcloth, cord and top grain leather. Twenty-three exterior color schemes are offered, including nine two-tone color arrangements.

Optional equipment items available are Ultramatic automatic transmission, power brakes, power steering, power windows, power adjusted seat, power operated radio antenna, air conditioning, dual heaters, tinted glass, four different radios and overdrive transmission.

Packard's Patrician, shown, like other models, is fitted with squeal-resistant tires. Tread design is said to provide better traction as well as eliminate irritating squeal when cornering. Tubeless tires are offered as special equipment for the first time on any American passenger car.

Packard Caribbean, custom-built sports car, has a 212 horsepower engine and as standard equipment, the Ultramatic transmission, power brakes, power steering, power seats and power windows.

Clipper Special club sedan displays restyled rear fender and tail light. A four-door sedan and hardtop are made in the Clipper DeLuxe series. Horsepower in the Clipper DeLuxe series has been increased from 160 to 165 in the 1954 models.

CHEVROLET

MORE power, restyled interiors, a wider choice of exterior and interior colors and color combinations and various mechanical improvements are the high spots of the new Chevrolets. The 115 horsepower engine used with Powerglide transmissions in the '53 models is now used with conventional transmissions, while engines used with Powerglide are now rated 125 horsepower.

Higher valve lift, redesigned hydraulic tappets and stronger camshaft are used in the 125 horsepower engine. Compression ratio has not been increased to attain the additional ten horsepower.

Clutch and transmission have been redesigned for greater reliability and smoother operation. Pressure-plate driving lugs in the clutch have been replaced by spring-steel driving straps to eliminate any possibility of the lugs binding in the mating slots of the clutch cover and to assure full-pressure contact with the driven disk. All transmis-

Chevrolet

Engine Specifications

	Standard	Powerglide
Type	OHV, in-line	OHV, in-line
No. cyls.	6	6
Bore & stroke (in.)	$3\frac{9}{16}$ x $3\frac{15}{16}$	$3\frac{9}{16}$ x $3\frac{15}{16}$
Displ. (in.³)	235	235
Comp. ratio	7.5 to 1	7.5 to 1
Bhp, max	115 @ 3700 rpm	125 @ 4000 rpm
Torque, max (lb-ft)	204 @ 2000 rpm	

Size and Weight

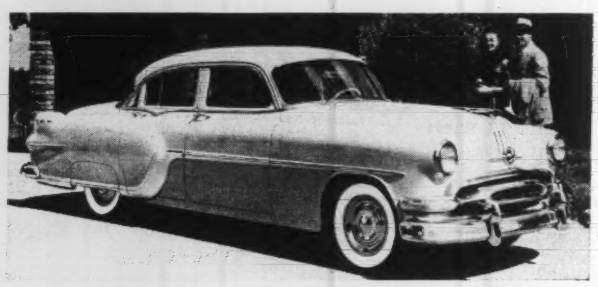
Wheelbase (in.)	115
Length, overall (in.)	195
Width, overall (in.)	74¾
Height, overall (in.)	$63\frac{1}{16}$
Shipping weight (lb)	3275

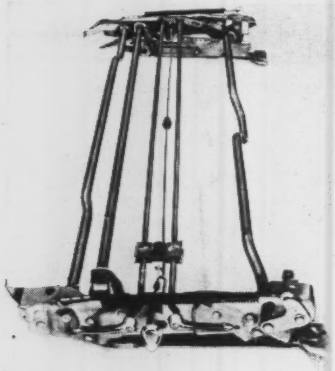
*Bel Air four-door sedan

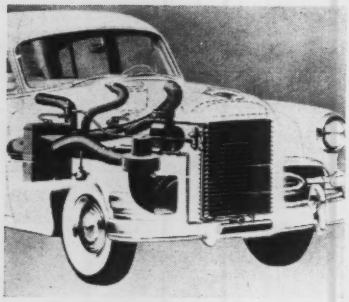
sion gears are now shot-peened and more liberal use of needle bearings is made in the transmission. A new 30-inch muffler improves silencing.

Redesigned grille, bumpers, bumper guards and tail lights are used on '54 Chevrolets. Power steering, power brakes, electric front seat adjustment and window lifts as well as automatic transmission are available as optional equipment. Nine of the 14 solid exterior colors are new. Two-tone interiors use vinyl, nylon-faced cloth and other modern fabrics.

PONTIAC







BIGGER, longer and more luxurious are the new Pontiacs. Wheelbases have been increased; overall length of a new series, the Star Chiefs, is 11 inches greater than previous Pontiacs. Selection of both interior and exterior colors and color combinations is said to be wider than ever before. Interior fabrics include nylon and durable coated fabrics.

Mechanical changes include increased horsepower and higher compression ratios for both six and eight-cylinder engines. New carburetor, intake manifold and current and voltage regulator are used with the eight. A new regulator, distributor and valves have been added to the six.

A full complement of optional accessories is offered this year. Power brakes, front seat with tilt or raise features, automatic electric window lifts, instrument panel safety cushion, air conditioning for eight-cylinder models, power steering and Dual-Range Hydra-Matic transmission are all available.

Pontiac's Star Chief is identified by three chrome stars on the rear fender fin. Interior trim is leather and nylon. Wheelbase and overall length of the Star Chief place it in the same size class as the largest cars. Lengthened rear springs improve ride and redesigned body mountings reduce vibration and noise.

Operating mechanism of Pontiac's Comfort Control front seat provides 360 different positions. The center knob at the bottom of the picture controls backward and forward motion of the seat. The two flanking levers control tilt and elevation.

This air-conditioning system offered as a factory installed accessory on 1954 Pontiacs, is mounted entirely under the hood. Other systems have certain of the components mounted in the trunk. Air enters through a duct at the right-hand side of the engine which is divided to allow mixing cool and uncooled air. Air is cooled by the evaporator under the right-hand fender before entering the car through two adjustable nozzles at each end of the instrument panel and through a valve outlet in the controls mounted on the instrument panel. The compressor is mounted on the front right-hand side of the engine and the condenser is between the grille and radiator.

Pontiac

Engine Specifications

	Chieftain 6	Chieftain 8, Star Chief
Type	L-head, in-line	L-head, in-line
No. cyls.	6	8
Bore & stroke (in.)	$3\frac{9}{16}$ x 4	$3\frac{7}{8}$ x $3\frac{3}{4}$
Displ. ($in.^3$)	239.2	268.4
Comp. ratio	7.7 to 1*	7.7 to 1*
BHP, max	118 @ 3800 rpm*	127 @ 3800 rpm*
Torque, max (lb-ft)	197 @ 2000 rpm*	234 @ 2200 rpm*

*Compression ratio, bhp and torque given are used with Hydramatic transmissions. Values are lower for synchromesh equipped cars.

Size

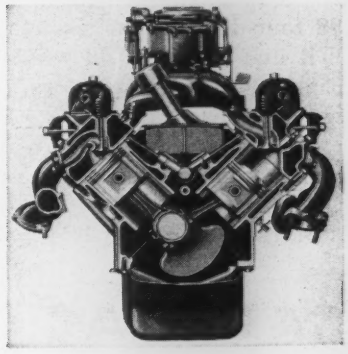
	Chieftain 6, Chieftain 8	Star Chief
Wheelbase (in.)	122	124
Overall length (in.)	202.66	213.66
Overall width (in.)	76.64	76.64
Overall height (in.)	63.24	63.24

BUICK

WRAPAROUND or panoramic windshields, an overhead-valve, V-8 engine for the Special series, and a Century series to be priced between the Special and the Super series are new Buick developments. Horsepower in the Super and Roadmaster engines introduced in 1953 has been increased by changing piston and combustion chamber design.

New to the Buick line for 1954 is the all-metal station wagon in the

new Century series. Powered by a 200-horsepower Roadmaster V-8 engine on a 122-inch wheelbase chassis, the Century is the outstanding performer in the Buick line. Front body posts slope to the rear on Century and Special models and doors are cut to fit around the windshield.



Built-in sun visors and rain coves which project over the tops of the windows are styling innovations introduced on 1954 Buick Roadmaster and Super four-door sedans. Rain coves permit opening windows for ventilation in a downpour. Fender ports have been restyled and the Buick "sweepspear" has been refined. Front body posts are vertical, as shown here on the Roadmaster, on Roadmaster and Super models. Wraparound windshield is said to eliminate blind spots.

A new feature of the power braking system which is standard on Roadmasters and available as optional equipment on Dynaflow equipped models is an electrically operated vacuum pump which provides sufficient vacuum for brake operation whenever the ignition switch is turned on. A relay automatically starts the vacuum pump whenever engine speed is below 300 rpm. When engine speed is more than 300 rpm, the vacuum pump automatically cuts out.

Sloping door lines and full rear wheel openings, sports-car style, are used on all convertibles and hard-tops. To add an additional sports-car touch, wire wheels are offered as optional equipment on all series except the Special.

Power brakes, power steering, Dynaflow automatic transmission and an improved air conditioning unit are available as optional equipment. The air conditioner is available only on two-door and four-door sedans in the Super and Roadmaster series. An innovation on the 1954 air conditioner is a solenoid clutch which disconnects the compressor from the drive pulley when the air conditioner is turned off. Compressor life is thus lengthened and the necessity of disconnecting the air conditioner during winter months is eliminated.

Engine Specifications

	Special	Super	Roadmaster, Century
Type	OHV, Vee	OHV, Vee	OHV, Vee
No. cyls.	8	8	8
Bore & stroke (in.)	3⅝ x 3.2	4 x 3 13/64	4 x 3 13/64
Displ. (in.³)	264	322	322
Comp. ratio	8.1 to 1*	8.5 to 1*	8.5 to 1*
Bhp, max	150 @ 4200 rpm*	182 @ 4100 rpm*	200 @ 4100 rpm*
Torque, max (lb-ft)	240 @ 2400 rpm*	300 @ 2000 rpm*	309 @ 2400 rpm*

*Compression ratio, bhp and torque given are used with Dynaflow. Values are slightly lower for synchromesh equipped cars.

Size and Weight

	Special	Century	Super	Roadmaster
Wheelbase (in.)	122	122	127	127
Overall length (in.)	206.3	206.3	216.8	216.8
Overall width (in.)	76.8	76.8	79.9	79.9
Overall height (in.)	60.5	60.5	62.4	62.6
Shipping weight* (lb)	3714	3786	4020	4212

*Estimated

New V-8 engine for 1954 Buick Specials has a newly designed combustion chamber which increases power and efficiency. The piston skirt has been lengthened nearly ¼-inch for improved stability and longer wear. The new engine has the same upright valve arrangement and the same cam-contoured counterweights on the crankshaft as the V-8 introduced in the Roadmaster and Super series in 1953.

OLDSMOBILE

LONGER, lower, wider and more powerful may all be used to describe the 1954 Oldsmobiles. Wheelbase has been increased by 2 inches, length and width are about 1¼ inches greater, and overall heights have been reduced 3 inches. Horsepower of the 88 has been increased from 150 to 170, Super 88 and 98 from 165 to 185. Power increase is the result of increases in engine displacement and compression ratio. Tests of the new engines have shown increased fuel economy accompanies increased power.

A full complement of optional equipment is available. Power steering, power brakes, power seats, the Autronic Eye automatic headlight dimmer, air conditioning, and Hydra-Matic transmission may all be had at extra cost. All of these accessories have been improved.

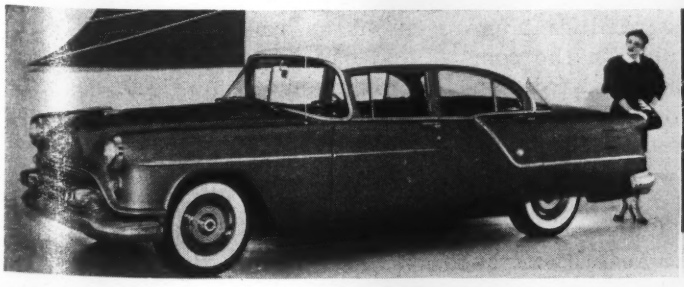
Wraparound windshield, cowl-wide ventilator opening and sweep cut fender are new styling features of the 1954 Oldsmobile as shown here on the Super

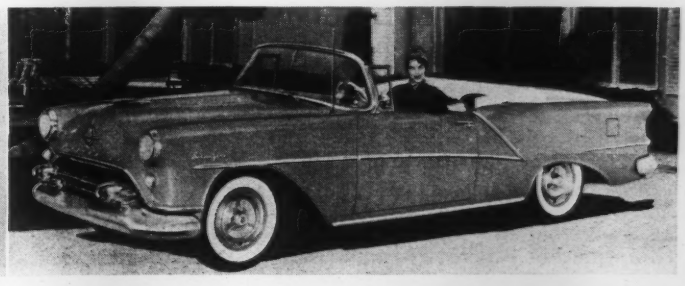
Engine Specifications

	88	Super 88, 98
Type	OHV, Vee	OHV, Vee
No. cyls.	8	8
Bore & stroke (in.)	3⅞ x 3 7/8	3⅞ x 3 7/8
Displ. (in.³)	324	324
Comp. ratio	8.25 to 1	8.25 to 1
Bhp, max	170 @ 4000 rpm	185 @ 4000 rpm

Size & Weight

	88	Super 88	98
Wheelbase (in.)	122	122	126
Length (in.)	205.26	205.26	214.26
Width (in.)	78.26	78.26	78.26
Height (in.)	60.5	60.5	60.5
Shipping weight (lb)	3692	3734	3846

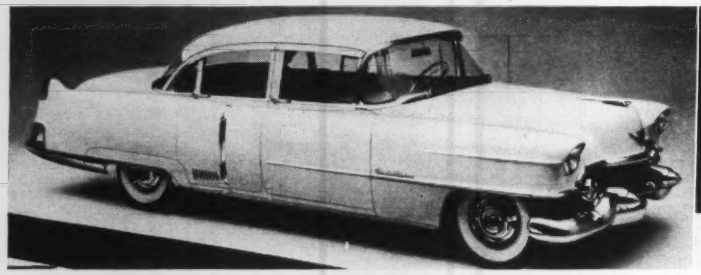


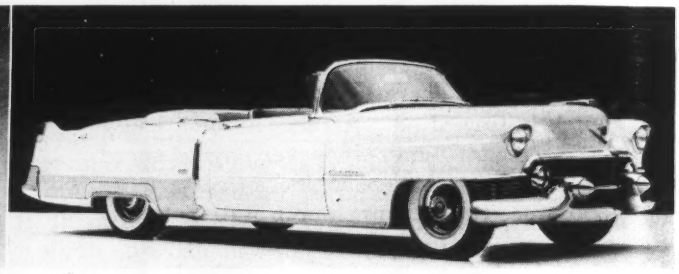


88 four-door sedan. Sports car-like treatment of the belt line at bottom of windows is another innovation. Eight new exterior colors are offered in addition to ten held over from '53. Forty-nine two-tone combinations are available. New colorful interior upholstery materials include nylon, vinyl-coated fabrics, Orlon and leather.

Starfire 98 convertible is Oldsmobile's bid for popularity in the sports car class. Both front and rear fenders are sweep cut in more radical fashion than other models. Top and windows are hydraulically operated. In addition to single-color exteriors, a unique two-tone finish is available with the area below and to the rear of the chrome side molding painted one color while the area above the molding is finished in a contrasting color.

CADILLAC





TWENTY more horsepower brings Cadillac in second in the horsepower race with 230. Horsepower increase is attained with no increase in engine displacement or compression ratio and is presumably the result of improved fuel induction and exhaust systems and possibly improved combustion chamber design.

Power steering is standard on the new models. The power steering unit is a new, simpler, more compact unit with a new steering ratio to reduce wheel turning. Another standard equipment item is the Hydra-Matic transmission which has been improved by an increase in efficiency of the fluid coupling and reduction in size and weight. New shifting smoothness is also claimed for the improved transmission.

Cooling system, fuel pump, electrical system and ignition system have been improved. New brakes have a ½-inch groove cut in the primary lining to increase brake life by improving heat distribution and eliminate hot spots. Frame and both front and rear end suspension have been redesigned to lengthen wheelbase by 3 inches and provide smoother riding.

Power brakes, a new dual fresh-air heating system, power windows, power seat adjustment, signal-seeking radio, the Autronic Eye automatic headlight dimmer, and air conditioning are available as optional equipment. This year's air conditioner has a solenoid-operated clutch to disengage the compressor from its drive when air conditioning is turned off.

Engine Specifications

Type	OHV, Vee
No. cyls.	8
Bore & stroke (in.)	3 13/16 x 3⅝
Displ (in.³)	331
Comp. ratio	8.25 to 1
Hp, max	230 @ 4400 rpm
Torque, max. (lb-ft)	332 @ 2800 rpm

Size

	Series 62	Series 60	Series 75
Wheelbase (in.)	129	133	149.8
Length (in.)	216.4*	227.4	237.1
Width (in.)	80	80	80
Height (in.)	62.1†	62.1	63.9

*Coupes, 223.4 †Coupes, 59.7; convertible coupes, 60.1

Wraparound or panoramic windshield, a new grille, and headlight "eyebrows" are the outstanding styling changes in the 1954 Cadillac. Built-in sun visor, and overhanging door reveal moldings to permit ventilation in a downpour, are standard on all sedans. All coupes, which appear to be of the "hardtop" variety, have sports-car styled doors as shown here on the Eldorado convertible. Power steering, power brakes, power seat adjuster, wire wheels, dual heaters, radio and white-sidewall tires are all standard on the Eldorado.

Report on Computer Performance

Completed in May of 1950, the National Bureau of Standards Eastern Automatic Computer, SEAC, has been in operation for more than 25,000 hours since that time on a seven-day week and 24-hour day. Approximately 25 per cent of the machine's operating time has been devoted to continued expansion of its capabilities. Number of vacuum tubes in the computer has been increased from approximately 750 to 1300 and germanium diodes from 10,500 to 16,000. Memory has been doubled.

Of the 11,000 hours of "good time"—scheduled time exclusive of development, maintenance and out of order time—between September 1, 1950 and May 1, 1953, 6270 hours have been spent on two problems which were very large and had many ramifications. Approximately 84 projects used the computer during the remaining 4730 hours. Representative of these problems are computation of Loran tables, solution of second-order nonlinear differential equation describing the orbits of elec-

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SEAC computing room at the National Bureau of Standards. Control console is at the far end of the room, and the computer proper is at the left. To the right are several of the external storage units which store on magnetic tape such information as coded subroutines, instructions to the machine, and numerical data, as well as the entire coded program for a problem and its solution when the computation is completed

trons through a cavity, and computing the simultaneous nonlinear equations describing the shock waves following an explosion.

During the three years SEAC has been operating, approximately 2500 type 6AN5 electron tubes have been used in the machine. More than 2/3 of the tubes used in the machine are of this type. Since tube rejections are made almost exclusively during established maintenance periods, operational failures are few. During one 15 month interval, it was necessary to replace only 18 tubes during the machine operating time. Studies of the data obtained show tubes used in the arithmetic and control units of the computer have a median life of 12,000 hours. Median life of 6AN5 tubes in the entire machine is 8700 hours.

Over a two-year period covering 15,819 hours of operation, total failures of germanium diodes were 0.3 per cent of those under study, or 0.02 per cent per thousand operating hours. During a certain one-year period 848 diodes in a group of 12,000 were replaced because they failed to meet specifications during preventive maintenance checks, although they were not causing trouble.

Operating efficiency of SEAC is defined as the sum of problem-solution time, code-checking time and idle-in-order time divided by the total time assigned to computation time. Down-time is the portion of scheduled time in which production is lost because of machine malfunctions, diagnosis and correction of the malfunctions and computation of problems not completed as a result of machine difficulties. Efficiency for the best quarter was 82 per cent, and during the week of October 27, 1952, efficiency of 93.5 per cent was achieved for the 124 hours of assigned time. Average efficiency from the time of initial operation until November 1953 has been 72.5 per cent.

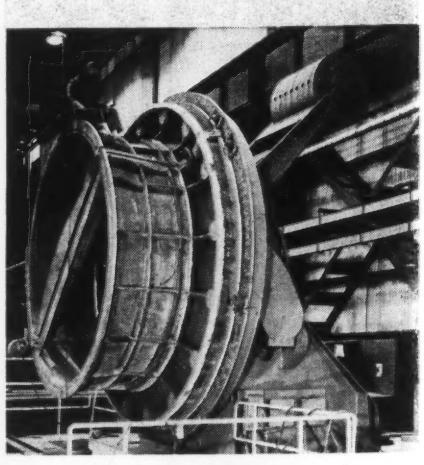
World's aircraft speed record was recently regained by the U. S. Air Force at Salton Sea, Calif., when an F-100 Super Sabre flew over a 15 kilometer course at speeds of 767.26 and 742.684 mph for an average speed of 754.98 mph. Previously the record was held by a U. S. Navy F4D Skyray with a speed of 753.4 mph.

Dictation Machine Records on Magnetic Belt

A continuous magnetic belt used as the recording medium in a new type of all-electronic dictating machine has a 15 minute recording time limit, can be mailed or filed easily, and can be reused an almost limitless number of times. Extremely faithful voice reduction is said to result from use of the magnetic belt with which no needle or stylus comes in contact. The machine is a joint development of Pierce Dictation Systems Inc. and the Armour Research Foundation.

One of the more interesting features of the device is the ability to record corrections directly over the incorrect portion by simply backing the belt to the proper point and redictating. Necessity of marking a correction slip is eliminated and there is no

WORLD'S LARGEST welding positioner rotates 40 ton weldments to facilitate semi-automatic down-hand welding. Manufactured by the Worthington Corp. and used by the S. Morgan Smith Co., the positioner has counterweights totalling 10 tons and a special hoist to lift the welder to the desired position above the weldment



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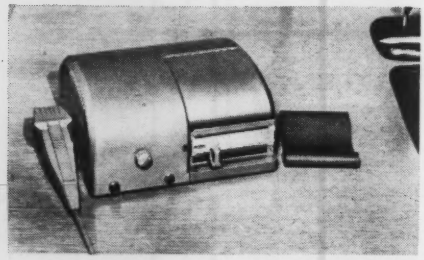
danger of the transcriber not catching the correction. There is no correction as far as the transcriber is concerned.

All controls—dictate, listen and back-up—are on the hand microphone which also serves as the playback medium for listening to what has been dictated. The microphone incorporates an automatic sound-level control which assures clear recording regardless of the intensity of the dictator's voice.



Lightweight, attractive dictation unit uses magnetic belt shown on the desk as recording medium

Though the dictating unit may be used for transcription, a separate transcribing unit is available with earphones, foot controls and built-in volume and tone controls. An automatic backspacer allows the transcriber to listen to the last two or three words typed when it has been necessary to stop for some reason.

Over 112 million tons of steel were produced in 1953 — largest production during a year in this or any country. No indication of a substantial setback looms in the near future although aggregate demand for steel is moderately reduced from the last few months of 1953. At the beginning of 1953 the annual steelmaking capacity in the United States was around 117.5 million tons, an increase of more than 25.6 million tons or 28 per cent, since the end of World War II. Because of the growth of the industry, nearly as much steel was made in September 1953 at 92.4 per cent of capacity as in September, 1952, when the average was 102 per cent of capacity. As much steel could have been made at 88 per cent in 1953 as at 100 per cent in 1950.

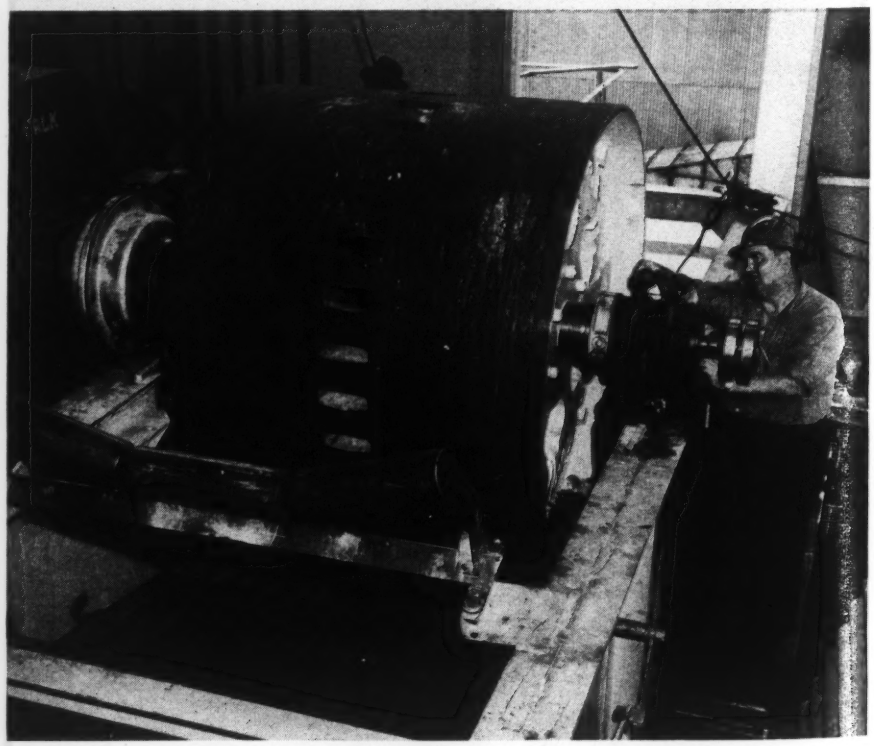
New Bronze-Plating Process

A readily-controlled process for bronze-alloy plating has been developed at Battelle Institute under sponsorship of City Auto Stamping Co. Known as "Lustralite," the process has demonstrated several engineering and decorative applications in laboratory studies. In one application, hydraulic pumps are produced with adherent bronze electroplated on the bearing surfaces. In this application, bronze-plated steel and bronze-plated iron castings furnish a combination of good bearing properties, high strength, and simple design.

In other applications, the bronze plate produced by this process has been shown to be an excellent material for facing valve seats. It also provides a fast and easy method for depositing bronze-alloy plate for use as a stop-off against the penetration of nitrogen gas in the nitriding process for surface hardening. The bronze-alloy deposit produced by the process is nearly three times as hard as copper plate, yet is deposited in ductile condition with a uniformly fine grained structure.

Three compositions of the cop-

KING-SIZE PULLEY: Largest electromagnetic pulley in the world, 60 inches in diameter with a 48-inch face, has been installed in the Oak Creek Power Station operated by Wisconsin Electric Power Co. Built by Stearns Magnetic Inc., the pulley will magnetically remove tramp iron from the coal used at Oak Creek to prevent damage to expensive crushers and other equipment. A unique feature of this pulley is the lagging, a thin, tough strip of material with firmly embedded granules that provide three times the traction of rubber lagging without belt wear and permit maximum use of the pulley's magnetic strength. The lagging is held to the face of the pulley by an adhesive



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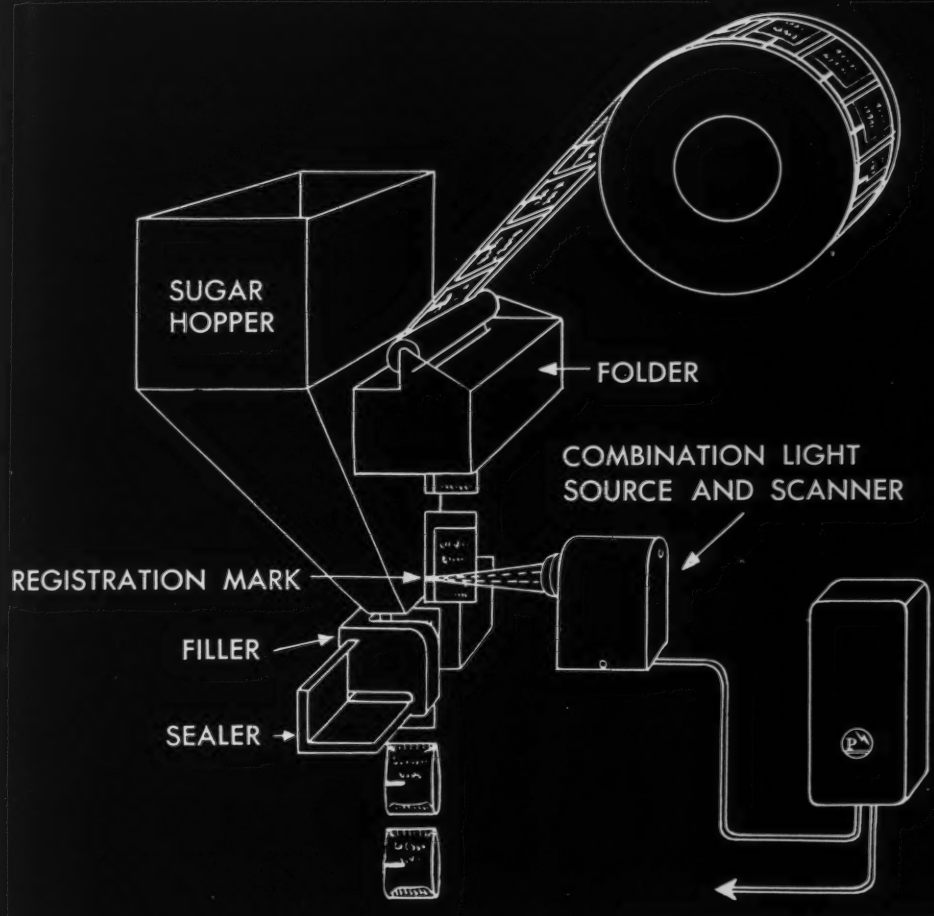

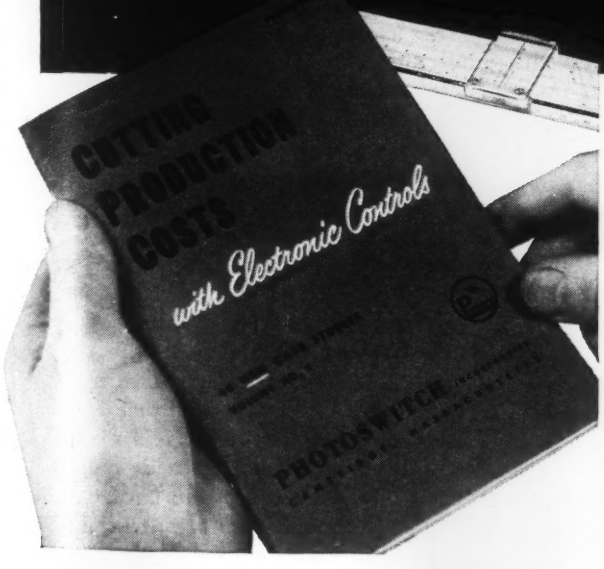

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The designers of this machine wanted to package sugar in small paper envelopes with a trade-mark properly positioned on each package. To minimize production costs, trade-marks were preprinted on paper webbing and converted into envelopes in the filling and sealing process. An extremely precise inspection and control device was needed to assure filling, cutting and sealing in register with the trade-mark. Photoswitch high-speed Photoelectric Registration Control was selected. Between 7000 and 9000 portions an hour are packaged automatically . . . without manual inspection of trade-mark location.

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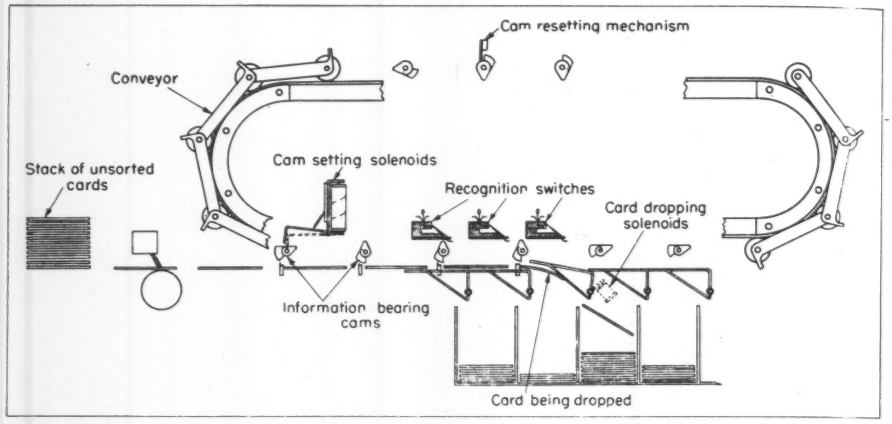
per-tin bronze-alloy deposit are recommended for different purposes. One composition produces ductile plate, Knoop hardness 260-280, particularly effective as a bearing overlay. Another is a slightly harder, gold-yellow plate that buffs easily to a mirror finish and is an undercoat to decorative plating. Chromium can be plated directly on this plate after buffing, or after depositing a very thin bright nickel plate. This composition plus chromium is said to be superior to an equal thickness of copper plus chromium in protecting steel against corrosion. A third composition produces a silvery, very hard (about 400 Knoop) plate unusually resistant to tarnish and scratching and suitable for inside automotive hardware, for flatware and reflectors.

Conveyor Belt Sorter

Incorporating a new sorting method, a sorting machine recently developed by the National Bureau of Standards sorts punched cards at the rate of 420 cards per minute. The principle, however, is applicable to sorting other objects, such as mail, electrical and mechanical components, and even farm produce.

Objects to be sorted are examined at one station, fed into a conveyor, and simultaneously a mechanical address number is put into each section of the conveyor belt so that the object and its address number travel together. When the object reaches the correct address, or location, a simple recognition device is excited, and the object is removed from the conveyor. The machine consists of five major components: (1) a sensing unit, (2) an addressing device, (3) a conveyor belt, (4) a series of recognition devices, actuated by the information-bearing mechanism of the conveyor belt, and (5) a series of receptacles or gates to other devices into which the material is sorted.

The NBS machine contains a track on which the cards are pushed by fingers extending down from the conveyor belt directly above. The conveyor belt conveys information in coded form, and the cards are kept in the correct physical location with respect to the address number by the pusher fingers. The conveyor belt is made from two parallel chains whose links are four inches on center and are connected by a crossbar at each card position. Each crossbar carries two nylon wheels on which the chains travel and eight nylon cams that act as the mechanical binary address number.



Schematic diagram of NBS conveyor belt card sorting machine. When the recognition switches are actuated by the cams on the conveyor the card is dropped into the pocket below

Each of the cams can be set to one of two positions (corresponding to the binary zero or one) with the point either down or up. They arrive at the starting end of the conveyor in the clear or zero position. To tip the cam upward, a pawl is moved into its path. Eight cams, each with two possible positions, provide 2^8 or 256 possible binary addresses. Since in general there are 2^n different addresses possible with n cams, the number of categories into which a quantity of items may be sorted is limited only by the number of cams carried.

In the sorting operation, the cards are first dealt from the bottom of the stack and pass under a conventional 80-column card reader. When the information on the card is decoded, an electrical device decides into which pocket the card is to go and the cams are set up with the correct address number. As the cams move down the conveyor with their associated cards, they pass under a series of switches, one set at each pocket. By properly wiring a set of eight switches, any particular 8-digit binary address number can be recognized, exciting a mechanism that will deflect the card from the track into a pocket.

While conveyor belt sorters of this general type are not new, the NBS machine has several definite advantages. It is not a synchronous machine; the card spacing in the conveyor does not have any relation to the spacing of the pockets. This leads to a saving in the power supply inasmuch as the cards are not usually all dropped simultaneously. Large sections of the belt may be added, as well as groups of pockets in any desired spacing, but the recognizing element in all cases must be spaced a constant distance from its associated pocket. It is also a simple matter to provide more than one pocket for one category; when one pocket fills, subsequent cards can be deposited in a second pocket.

A new bright copper plating process is said to be faster and easier to control in addition to saving nickel and eliminating the need for copper buffing. The process, developed by Smoothex Inc., is claimed to produce a sparkling, brilliant finish using standard plating equipment.

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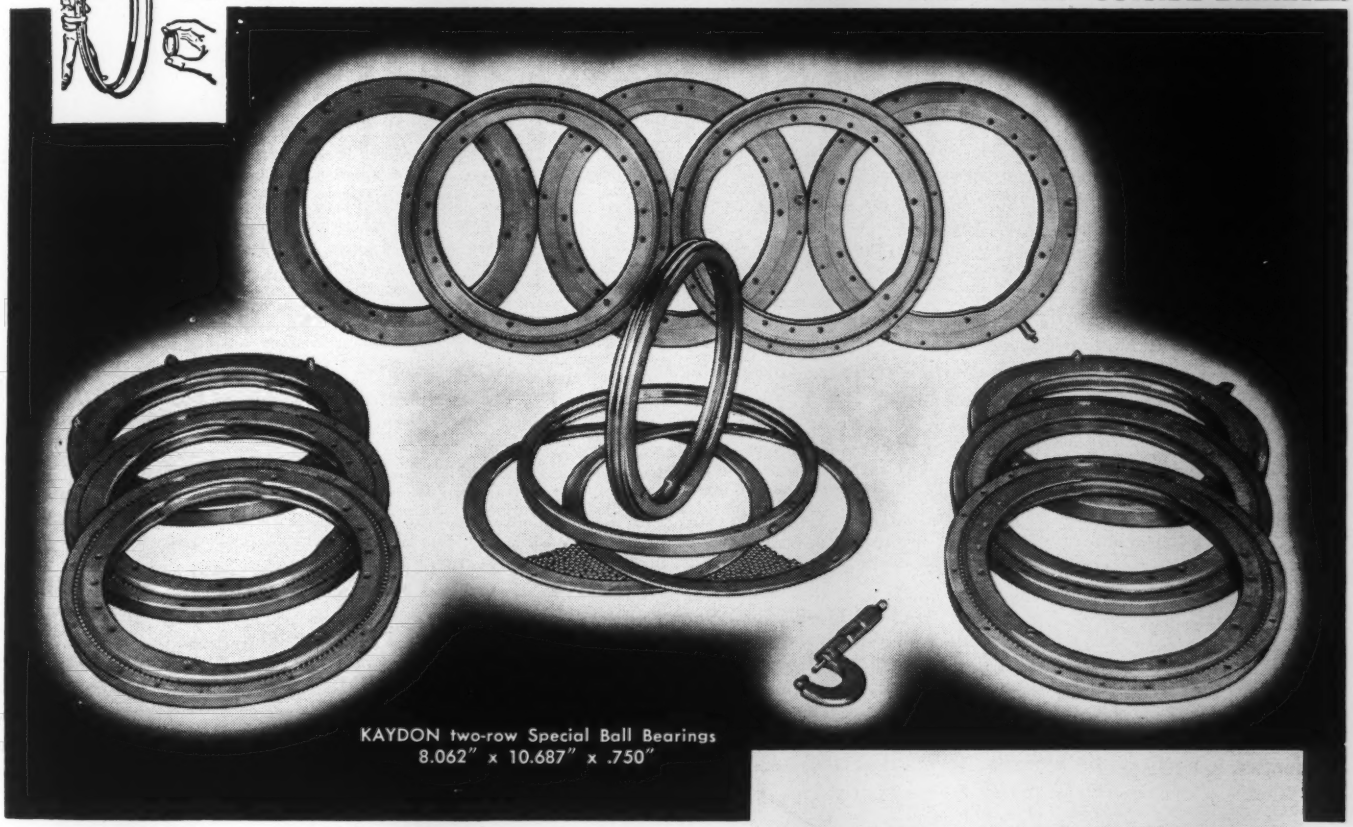

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8.062" x 10.687" x .750"

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PRECISION BALL AND ROLLER BEARINGS

Helpful Literature

(*Continued from Page 212*)

35. Bimetal Disk Thermostats

Stevens Mfg. Co.—illustrated data sheet F-2009 describes type M bimetal disk thermostats for appliances, electronic devices and apparatus. Hermetically sealed and open types are included. Operating principle, ratings, performance curves, dimensions and construction are all covered.

36. Extruded Plastics

Anchor Plastics Co.—1954 edition of "Extruded Plastics" brochure contains 12 illustrated pages on custom extrusions, including some of the latest applications of thermoplastic rods, tubes and shapes. Facilities available for fabrication are summarized, and a section is devoted to material properties.

37. Low Inertia Clutch & Brake

Wichita Falls Foundry & Machine Co.—Low inertia Air-Tube clutch and brake described and illustrated in 4-page bulletin 110 is designed for use on punch presses, press brakes, shears and other machinery. Units are made in sizes from 8 to 48 in. Features are outlined.

38. Insulating Varnishes & Resins

Dow Corning Corp. — Comparison of the properties and performance of five coating and impregnating varnishes, an adhesive and six bonding and laminating resins is found in 4-page bulletin 10-227. Each is described individually and recommended applications are given.

39. Needle Bearings

Orange Roller Bearing Co.—Design and construction features and specifications for Orange cage type needle bearings are found in 4-page illustrated bulletin. The 7000 series is available without and with inner races. Outside diameters range from 1 to 3 in.

40. Centrifugal Pumps

Worthington Corp., Centrifugal Pump Div.—Suitable for wide variety of applications, line of standard and suction centrifugal pumps described in illustrated bulletin W-300-B4 offers maximum interchangeability of parts. Line covers six types with various mountings, frames and drives.

41. Manganese Steel Castings

American Brake Shoe Co., American Manganese Steel Div.—Description of complete line of castings made of "the toughest steel known," Amsco 13 per cent manganese steel, is found in illustrated general catalog. Impact and abrasion resistant characteristics are discussed under various product categories.

42. Telemetering Systems

Bristol Co.—Multiplexing transmitting and receiving system for use with Metameter Telemeters is subject of this illustrated bulletin. It describes system for transmitting up to 15 pressure, vacuum, temperature, flow, liquid level and other readings over a single circuit and given distance.

43. Minute Layouts

H. Owens Co.—The roll method of pattern layout, which does not use the rules of geometry, is subject of this well-illustrated step-by-step brochure. Pattern Developer which uses this method eliminates waste of time and material of other methods. Instructions for using the device are given.

44. Aircraft Electric Motors

U. S. Electrical Motors, Inc.—Total of 22 models of aircraft electric motors are illustrated and described in bulletin 1535. Range is from 1/20 to 16 hp. Motors are high frequency induction type for three-phase alternating current. Many include built-in gearing.

45. Valves, Regulators, Torches

Hoke, Inc.—Line of small valves, pressure regulators, stainless steel cylinders, flo-gages and oxy-gas torches is subject of detailed 38-page catalog No. 2. Also included are 28 pages of engineering data on the various types of valves, including needle, toggle, packless and special purpose. Needle valve controls, various types of pressure regulators, pressure gages, fittings, and stainless steel cylinders for pressure samples are covered.

46. Dual Vane Hydraulic Pumps

New York Air Brake Co., Dudco Div.—Selection data for line of Dudco dual-vane hydraulic pumps, along with design features, are found in 8-page illustrated bulletin DP-300. Technical drawings, cut-away photos and performance data charts are included for the single-stage pumps of constant delivery type for continuous operation at pressures up to 2000 psi.

47. Seamless Tubing

Columbia Steel & Shafting Co.—Sizes, working pressures, specifications and other engineering data on all types of seamless tubing produced by this company are included in 8-page illustrated booklet "Summerill Tubing." Sections are devoted to hydraulic, pressure, mechanical, diesel, special and aircraft tubing.

48. Self-Lubricating Bushings

Graphite Metallizing Corp.—Design and engineering data for Graphalloy self-lubricating bushings (which contain no oil) are in the 8 illustrated pages of form 112. Made of babbitt, copper and bronze metal impregnated graphite, they are also used as thrust washers, seal rings, electrical brushes and contacts.

49. Die Blades, Wear Plates

Ohio Knife Co.—Laid bronze wear plates, plus laid steel die sections and slides are described in 4-page bulletin. Wear plates are stocked in 72-in. lengths with widths up to 8 in. and thicknesses up to 1¼ in. Die section ranges up to 2½ x 4⅜ with 15/16-in. land and 1-in. base. Widths of the 120-in. long slides range up to 8 in.

50. Engine Supercharger

Dexter Folder Co., Miehle-Dexter Supercharger Div.—Supercharger made by this division for internal combustion engines as well as blower and air compressor operations is featured in 4-page bulletin 153. Models from 15 to 4000 cfm at pressures of 2 to 15 psig are available for engines with ratings from 100 to 750 hp.

51. Welding Rod Guide

Eutectic Welding Alloys Corp. — 32-page "DirectoRod Guide" offers recommendations for over 300 types of metal joining operations. Booklet is divided into sections, each dealing with specific base metal, and at the end of which is a chart listing electrodes, alloys and fluxes which may be used on the base metals. Highlights are over 40 illustrations of pracical applications taken from case histories and 12 pages of charts.

52. Stainless Steel Tubes

Globe Steel Tubes Co.—Available sizes, features and standard tolerances relative to seamless and welded stainless steel tubes are featured in 8-page bulletin S-222. Welded tube sizes range from ¼ to 5 in. OD, while seamless tubes range from ½ to 6 in. OD. They can be made to meet AISI, ASTM, AMS, FSTI, Military, Government and special specifications.

53. Use of Fiber Glass

Libbey-Owens-Ford Glass Co.—How to improve efficiency and reduce production costs of many products by using superfine fiber glass is the subject of 16-page form F-11. Entitled "Possibilities Unlimited," it suggests ways in which designers can apply superfine to decrease a product's overall weight, increase its cubic capacity and still maintain temperature control.

54. Plastics & Resins

Bakelite Co. — Latest information about more than 50 Bakelite and Vinylite plastics and resins, their properties and uses, is presented in 12-page revised reference file G-19. Data are compiled in 18 categories under these headings: molding and extrusion materials, wire and cable covering, bonded resins, protective coating resins, laminating plastics, rigid sheets, flexible film and sheeting and calendering materials.

55. Single Stage Turbine

De Laval Steam Turbine Co.—The HCB single stage turbine designed for variety of plant applications is reviewed and specified in 6-page bulletin 4206. Maximum operating conditions of this unit are: up to 100 hp, pressures to 300 psig, temperature to 550° F and speed to 4000 rpm. Dimensions and performance figures are tabulated.

56. Making Ceramic Models

American Lava Corp. — Step-by-step procedures for making models from Lava mined nugget stone (not volcanic material) are outlined in 4-page bulletin 525. It discusses the material, gives properties of available Lava blocks before and after firing and outlines firing procedures.

57. Rubber Products Facilities

Spencer Rubber Products Co.—Comprehensive brochure is descriptive of molded rubber design, development, short run and production run facilities available at this company. Feature of this profusely illustrated booklet is its chart which simplifies proper rubber specification.

58. Push-Pull Controls

American Chain & Cable Co., Automotive & Aircraft Div. — Designed for rugged but general utility applications where operation must be smooth and accurate, heavy duty hand operated Tru-Lay push-pull controls of the D-800 series are described in 4-page folder DH-310.

59. Trimming Potentiometer

Bourns Laboratories — Standard resistance values from 250 to 25,000 ohms are featured by new wire-wound trimming potentiometer, the Trimpot, described in 6-page brochure 3591. Specs cover vibration, acceleration, temperature coefficient of wire and operating temperature range.

60. Electric Tachometers

Madison Electric Products, Inc.—Standard line of Chicago electric tachometers for portable and permanent uses is subject of 4-page bulletin No. 9-53. Featured is new model 12M tachometer which has a 250-degree scale. Accuracy is ±2 per cent.

61. Porcelain Products

U. S. Stoneware Co.—"Chemical Porcelain" is title of 8-page bulletin CP-50 illustrating and describing line of products made of this material. Pipe, fittings, spacers, vertical check valves, stop check valves, hand-wheel valves, plug valves, swivel joints, expansion joints, sight glasses, flanges, ejectors and tower packing are covered.

62. Electronic Test Equipment

Cal-Tronics Corp.—In addition to describing company services and facilities, 12-page bulletin reviews various types of "Electronic Test Equipment" built by company. Shown are synchronizer test unit, electronic control amplifier test unit, computer systems test unit and signal data converter test unit. All meet Air Force specifications.

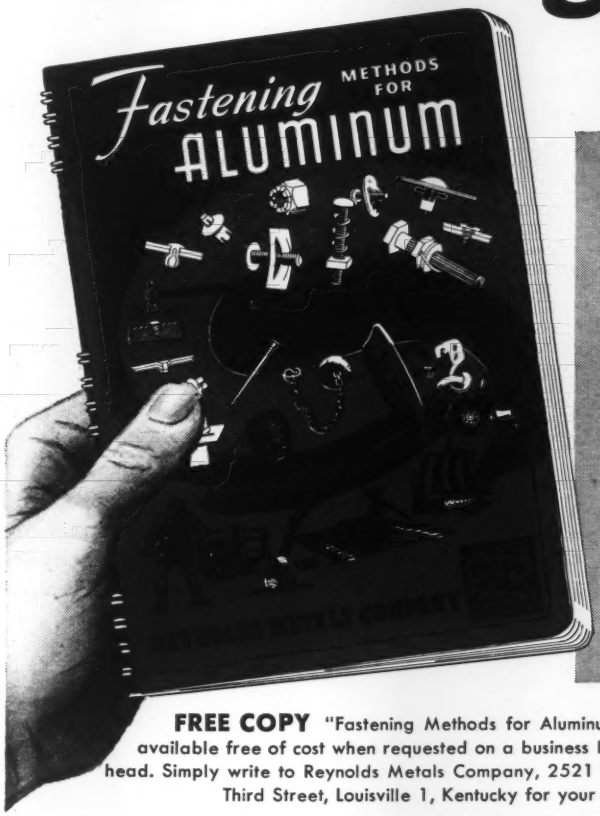
63. Synchronous Motors

General Electric Co.—Operation and control of synchronous motors is effectively treated in 16-page bulletin GEA-5873. It explains electrical operations of motors and areas where control is essential. Problems common to motor applications and their solution are explained in question-answer technique. Various control units are described along with rating and dimension data.

64. Planetary Speed Reducers

Philadelphia Gear Works—Improved planetary speed reducers are subject of descriptive 16-page catalog P-53. These in-line units are available in single, compound or double types, and horsepower ratings are A.G.M.A. Class 1. Standard ratios range from 4.3:1 to 10:1.

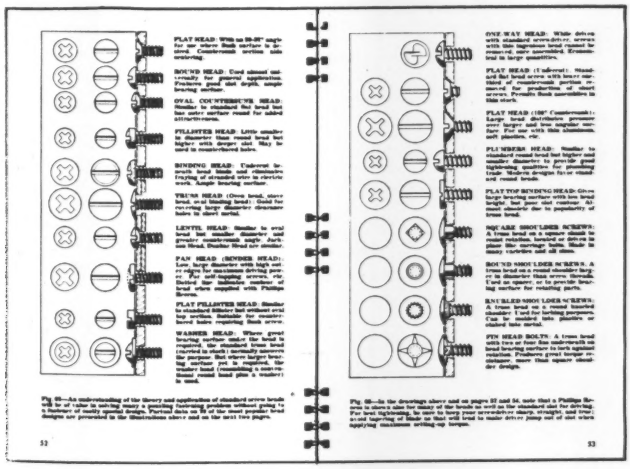
Fastening Aluminum?



136 PAGE HANDBOOK by Reynolds

Gives Complete Information

FREE COPY "Fastening Methods for Aluminum" is available free of cost when requested on a business letterhead. Simply write to Reynolds Metals Company, 2521 South Third Street, Louisville 1, Kentucky for your copy.



Typical Complete Subject Treatment Found in "Fastening Methods for Aluminum"

This highly authoritative handbook answers all questions on mechanical fastening methods for aluminum. It comprehensively covers such subjects as when and where to use

STANDARD RIVETS
SPECIAL RIVETS
STANDARD SCREW FASTENERS
SPECIAL SCREW FASTENERS
NAILS AND PINS
METAL STITCHING
MECHANICALLY FORMED JOINTS
RESIN BONDING

and discusses the advantages and methods for each type of fastening. It is complete with pictures, diagrams and charts. Whether you are a designer, production engineer or plant supervisor this handbook belongs on your desk because it will make your job easier.

SEE *"Mister Peepers"* Sundays NBC-TV. Consult local listings for time and station.

REYNOLDS ALUMINUM

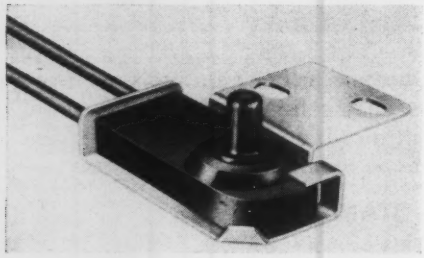
MODERN DESIGN HAS ALUMINUM IN MIND

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 211.

Waterproof Switch

All working parts of the No. 201209 molded plunger switch are waterproofed. The small rubber plunger can be fabricated to individual specifications. Overtravel is an inherent characteristic of this plunger. Bracket is of one-piece stainless steel construction. Switch is available in single-pole, single-

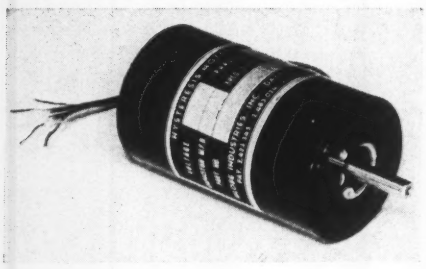


throw or single-pole, double-throw types. Waterproof covering can be made of vinyl, neoprene or silicone. Made by **Control Products Inc.**, 306 Sussex St., Harrison, N. J.

For more data circle MD-65, Page 211

Miniature Motor

Line of 400-cycle miniature hysteresis, synchronous motors is adapted for power, servo or timing applications. Measuring 1¼ in. diameter by 2¼ in. long, they are available with two or four-pole winding for 24,000 or 12,000 rpm. The motors operate at 115 v ac or less. For servo applications they can be wound for two-

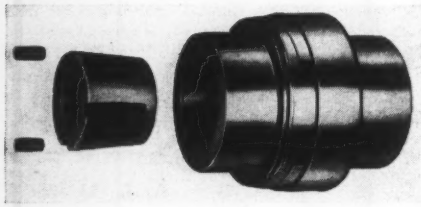


phase operation; for timing and power applications, they are available as single-phase capacitor-run motors. Rotors are mounted on double shielded, grease packed ball bearings. Stator windings employ Teflon insulated magnet wire, and the motor leads are wrapped Teflon insulated. Made by **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, O.

For more data circle MD-66, Page 211

Flexible Couplings

Three sizes of type C flexible couplings adapted for use with Dodge Taper-Lock bushings allow easy fastening to shafting with firmness of shrunk-on fit. Coupling sizes are C-191 (bushing No. 2012) for bores ½ to 2 in., C-226 and C-276 (bushing No. 2517) for

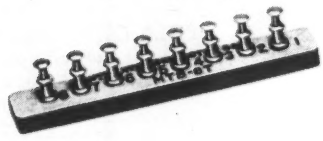


½ to 2½-in. bores. Made by **Lovejoy Flexible Coupling Co.**, 4818 W. Lake St., Chicago 44, Ill.

For more data circle MD-67, Page 211

Miniature Terminal Boards

Eight turret type terminals are molded directly into the body of the 1 9/16-in. long series MT mini-

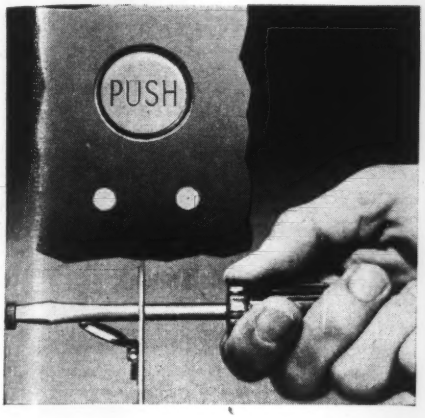


ature terminal board. Terminals are tinned to facilitate soldering. Standard molding material is mineral filled Melamine; Plaskon reinforced alkyd and diallyl phthalate types are also available from **De-Jur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

For more data circle MD-68, Page 211

Access Door

For use where frequent adjustments are made by screw drivers or similar tools and for lubricating points, stainless steel access door opens at pressure of the tool and automatically springs closed when the tool is withdrawn. Standard size of the rivet-mounted door is ¾-in. diameter; special sizes can



be made by **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J.

For more data circle MD-69, Page 211

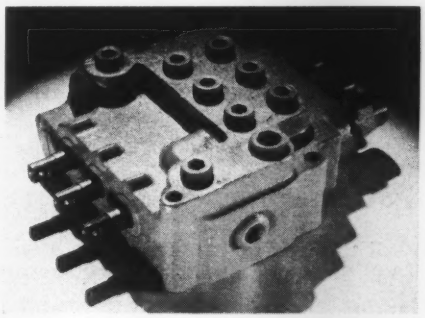
Automatic Speed Control

Automatic speed control of U. S. Varidrive motors by such variables as pressure, temperature, speed or liquid level is possible with the improved pneumatic Varitrol, which may be operated either manually or automatically. It operates on a supply air pressure of 60 to 100 psi and is controlled by an air cylinder using air on both sides of the piston for positive positioning. A small, sensitive positioner operating on 3 to 15 psi signal air controls a pilot valve regulating the power air to the air cylinder. Any one of a number of control instruments may be used as the signal system to the positioner. The control has an approximate straight line relationship between signal pressure and speed, which provides uniform sensitivity over the entire speed range. Presently available on Varidrives from 1 to 30 hp, Varitrol can be supplied up to 50 hp. Made by **U. S. Electrical Motors Inc.**, P. O. Box 2058 Terminal Annex, Los Angeles 54, Calif.

For more data circle MD-70, Page 211

Directional Control Valves

Spool groove on series of directional control valves for mobile equipment is coined straight down in a V-slot, permitting accurate control and smooth metering action. There is full metering in all spool porting. Valve is made in four sizes to allow flow of 8, 16, 23 or 35 gpm. Models include 1, 2, 3 and 4-spool types. Single and double acting spools are interchangeable. In the smaller sizes,

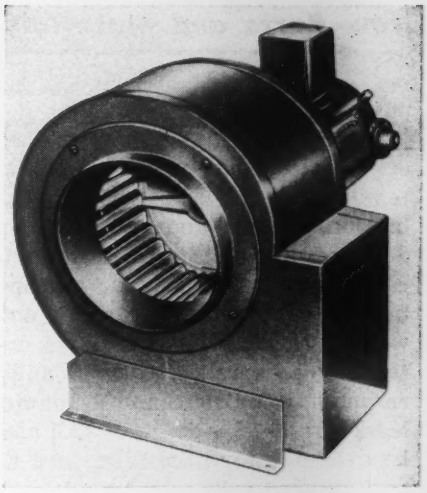


device can control pressures up to 2500 psi. Design allows flow characteristics to be tailored to user's needs, and full parallel circuit permits precise travel control in more than one direction. It is adaptable to simultaneous rotation, fork clamping, side shifting and up-ending operations. Made by **Parker Appliance Co.**, 17325 Euclid Ave., Cleveland 12, O.

For more data circle MD-71, Page 211

Ventilating Blower

Blower has 6-in. diameter wheel and a capacity of 600 cfm. It is provided with an automatic cut-out which stops the completely enclosed 110-v motor if overheating should occur. Unit is also available in smaller sizes with similar con-



struction. Made by **Standard Electric Mfg. Co. Inc.**, West Berlin 12, N. J.

For more data circle MD-72, Page 211

Tacky Adhesive

Resyn 35R2625, a permanently tacky, solvent type adhesive, is used to prevent small wood chips and dust from entering working mechanisms housed in wooden cabinets. Such chips and dust, released by the rubbing of metal parts on wood during assembly, are trapped by the adhesive painted on in areas of contact between the cabinet and parts. Made by National Adhesives Div., **National Starch Products Inc.**, 270 Madison Ave., New York 16, N. Y.

For more data circle MD-73, Page 211

Time Delay Relay

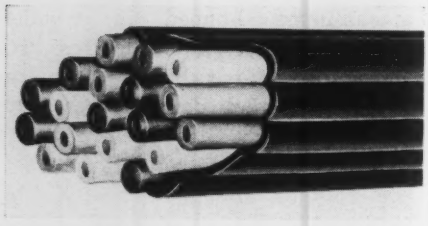
Usable in industrial control devices which operate in wet, corrosive, dusty or explosive atmos-

pheres, type SF Agastat time delay relay is lightweight, hermetically-sealed, unaffected by freezing temperatures and resistant to vibration, shock and acceleration. Solenoid-operated and pneumatically-controlled, relay has housing 2⅛ in. square by 4 in. high and weighs 1.2 lb. Time delay is externally adjustable from 30 milliseconds to more than 1 minute. Made for 24-28 v dc, relay will also be available for other standard ac and dc voltages. It has double-break contacts in single, double and three-pole models. Made by AGA Div., **Elastic Stop Nut Corp. of America,** 1027 Newark Ave., Elizabeth, N. J.

For more data circle MD-74, Page 211

Instrument Tubing Harness

Impervapak Poly-Cor is now available with color-coded lines to

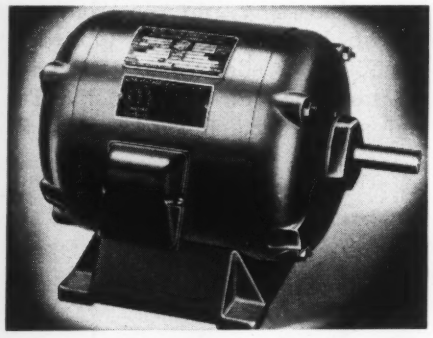


facilitate installation of instrument lines. Available with 4, 7, 10, 14 or 19 tubes and with individual lines coded in black, red, blue or green, the instrument harness is composed of a bundle of polyethylene tubes over which is extruded a 1/16-in. thick sheath of high molecular weight vinyl plastic. It is resistant to corrosion. Made by **Samuel Moore & Co.,** Dekoron Tubing Div., Mantua, O.

For more data circle MD-75, Page 211

Integral Horsepower Motors

New line of integral horsepower motors is designed to facilitate changeover to the new NEMA standards. All performance characteristics of the old and new motor lines are equal and contour lines and styling are the same. Only

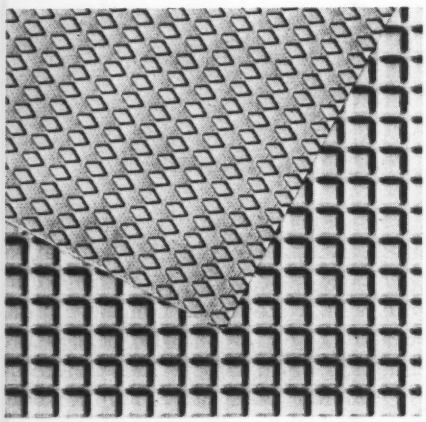


physical mounting dimensions vary. Both old and new mountings will be available in ratings of 1, 1½ and 2 hp. Other characteristics include rolled steel main frame, cast iron end frames and rotor fans integral with cast end rings and rotor bars. Present production includes 203, 182, 204 and 184 frames in all of above ratings. Subsequently 224, 213, 225 and 215 frames, and 3 and 5 hp ratings will be available. Made by Electric Motor Div., **A. O. Smith Corp.,** Tipp City, O.

For more data circle MD-76, Page 211

Patterned Metals

Rigid-Tex metal sheets are available in two new patterns, No. 1-SQ and 2-DD in widths up to 8 and 7 in. respectively. Available finishes are mill finish as rolled, mill finish with highlights, colorized and highlighted, and painted or porcelain enameled without highlights. Materials include solid and perforated sheet, strip and coil ferrous or nonferrous metals. Uses include automobile and appliance trim, scuff

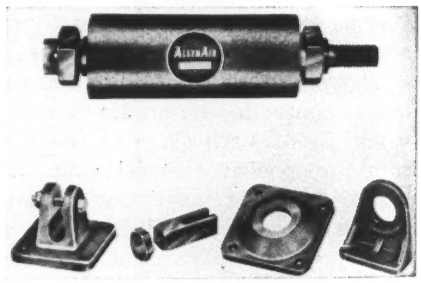


plates, door hardware and similar applications requiring eye-appeal, high strength to weight ratio and mar resistance. Made by **Rigidized Metals Corp.,** 693 Ohio St., Buffalo 3, N. Y.

For more data circle MD-77, Page 211

Double-Acting Cylinders

Line of double-acting cylinders for air, water or low-pressure hydraulic operation is available in 1⅛, 2 or 3-in. bore, any stroke, and with either single or double-ended piston rods. The cylinders have Thomson Nylined bearings and "Copper-brited" honed cylinder tubes for resistance to corrosion. Heads are fastened squarely and rigidly to the cylinder tube with rectangular section, hardened



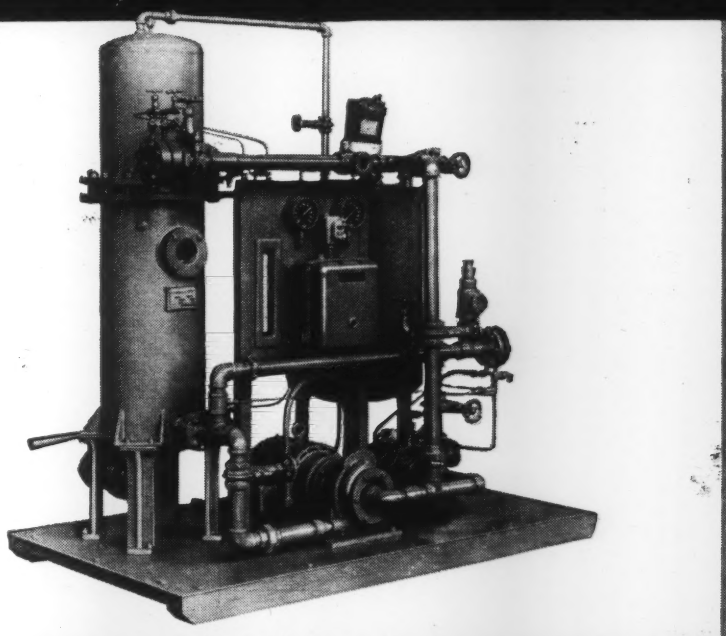
steel, snap rings reground flat and parallel and to 0.001-in. tolerance on thickness. Adjustable cushions are available front or back on the 2 and 3-in. sizes, and various interchangeable foot, flange and clevis mounts permit mounting in any manner or position. Made by **A. K. Allen Co.,** 57 Meserole Ave., Brooklyn 22, N. Y.

For more data circle MD-78, Page 211

Miniature Steel Balls

Fifteen sizes of RMB miniature chrome steel precision balls (SAE 52100) range in size from 0.350-mm (0.013780-in.) to 2.250 mm (0.088583-in.), including 1/64, 1/32 an 1/16-in. sizes. They have a sphericity tolerance of 0.000008-in. maximum. They are usually packed in 5000 to 50,000 ball lots, depending upon size, minimum packing

HOW TO FILTER WATER FOR OIL RECOVERY



Crane Wedge Disc Clamp Gate Valve . . . extra strong, extremely compact. Clamp design is ideal where easy cleanout may be required. Bonnet assembly and disc lift out —body stays in the line. O.S. & Y., inside screw, and quick-opening patterns, all-iron or brass trimmed. Screwed or Flanged ends. Sizes up to 4 in. Working pressures up to 150 psi saturated steam, 225 psi cold service.

another successful product design with piping equipment by CRANE

Water flooding for oil takes a lot of specialized water treating equipment. A prominent supplier is R. P. Adams Co., Buffalo, N. Y., whose field test filter unit for secondary recovery is shown here.

The Adams design provides permanent filter mediums and permits easy backwashing without disassembly. Built for rugged service, the unit is equipped with Crane piping materials for added dependability.

Dependability is the big reason, of course, why more and more design engineers specify from the familiar Crane Catalog. But they also know that here is a reliable source of valuable piping information. For each piping item, Crane provides the data you want . . . sizes and dimensions, temperature and pressure ratings, plus a run-down on materials and construction. Fully indexed, of course, to save you time.

YOU'LL FIND IT HERE ...IN YOUR CRANE CATALOG

THE BETTER QUALITY... BIGGER VALUE LINE... IN BRASS, STEEL, IRON

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

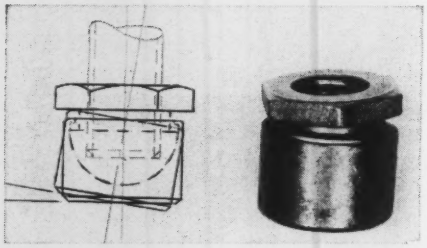
VALVES • FITTINGS • PIPE • PLUMBING • HEATING

being 100 balls per vial. Made by **Landis & Gyr Inc.**, 45 W. 45th St., New York 36, N. Y.

For more data circle MD-79, Page 211

Removable Clamp Shoe

Gulland Swiv-L shoe fits a standard thread like an ordinary nut.

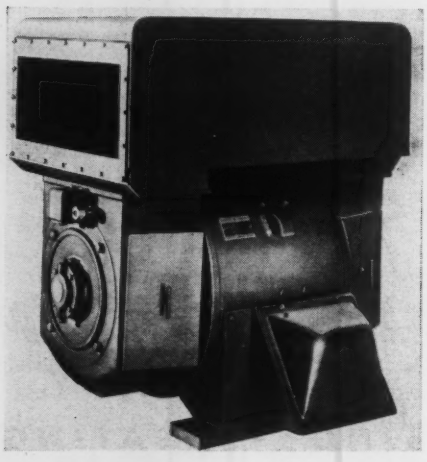


Swivel action of the shoe allows it to follow the contour of the work it is clamping without marring the surface. Manufactured in 12 different thread sizes from ¼-20 to ¾-16 by **Lance Mfg. Co.**, 31144 West Eight Mile Rd., Farmington, Mich.

For more data circle MD-80, Page 211

Cool Running Motor

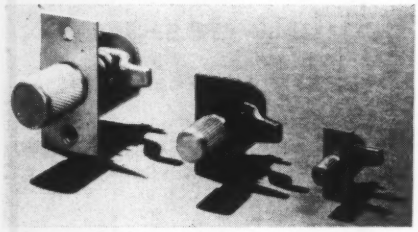
Available in ratings from 15 to 200 hp, this totally enclosed, unit-cooled dc motor provides 50 per cent greater heat transfer in a 37 per cent smaller unit than previous designs. A compact cooling unit, mounted completely within the overall length and width of the motor, permits operation at extremely low speeds for long periods of time because ventilation is independent of motor speed. A double system of blowers provides rapid cooling by forcing air through the external passages of the cooler while also forcing internal motor air through the closed internal passages of the air cooler. The blower motors operate on three-phase, 60-cycle power supply. Made by **General Electric Co.**, Schenectady 5, N. Y.



For more data circle MD-81, Page 211

Adjustable Pawl Fasteners

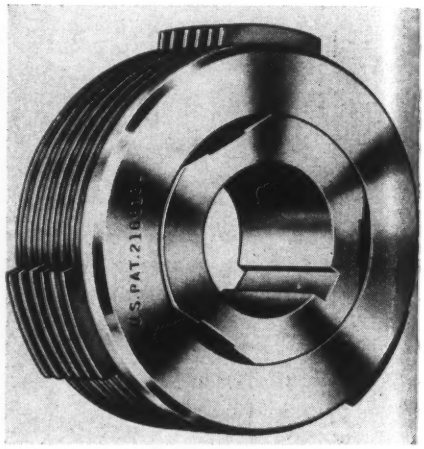
Designed for quarter-turn closure or opening of hinged doors and panels on machinery and equipment, Southco adjustable pawl fasteners are offered in large, medium and miniature sizes. The adjustable pawl unit tightens or loosens contact with the door jamb with an additional turn or two of the head. The fixed pawl type is preset at installation to the desired contact gap and tension. Knurled knob and T-bar heads provide convenient hand operation. Slotted flush head is available for screwdriver operation. Also offered is gasket for use in making fastener watertight if desired. Made by Southco Div., **South Chester Corp.**, Lester, Pa.



For more data circle MD-82, Page 211

Clutch Disk Assembly

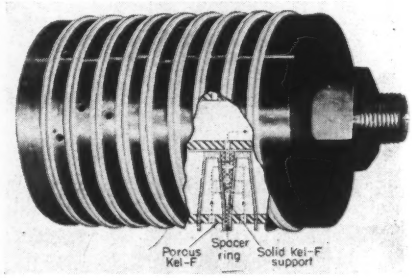
Self-contained and independent of the actuator, Maxitorq Disc-Pac is designed for use by those who wish to build their own clutches or brakes. Separator springs prevent drag, abrasion and heating in neutral; a locking plate locks all disks onto the body. Unit keys to shaft and is easily replaced. Eight disk diameters are available from 2 to 8 in. with ratings of ¼ to 15 hp at 100 rpm. Disc-Pak fits standard Maxitorq driving rings. Assembly, disassembly and adjustments are performed without tools. Made by **Carlyle Johnson Machine Co.**, Manchester, Conn.



For more data circle MD-83, Page 211

Plastic Filter

Compact in-line filters are available for use with highly corrosive materials. Porous filter medium is resistant to all common acids and gases in all concentrations, as well as to common organic chemicals. Filter elements remove all particles larger than five microns in liquid filtration and much finer particles in gas filtration. They can be used at temperatures up to 350 F and are resistant to thermal shock. Tensile strength of the filter medium



a "lubrication fitting" that out-thinks a man...

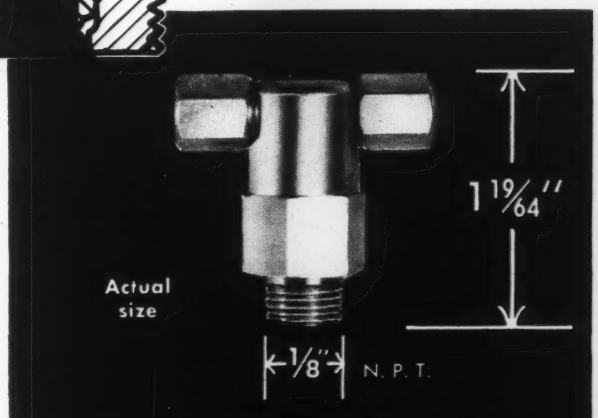
ALEMITE Accumeter®

The low-cost, simple way for you to design fool-proof, automatic lubrication into a machine with many small bearings

Many small bearings on a compact, high-speed machine. You know that proper, exact lubrication is essential, but you also know how crowded the bearings will be. You know that they will be difficult or impossible to reach with grease gun or oil can and that some of them will be missed—and the shutdown time for lubrication will be costly.

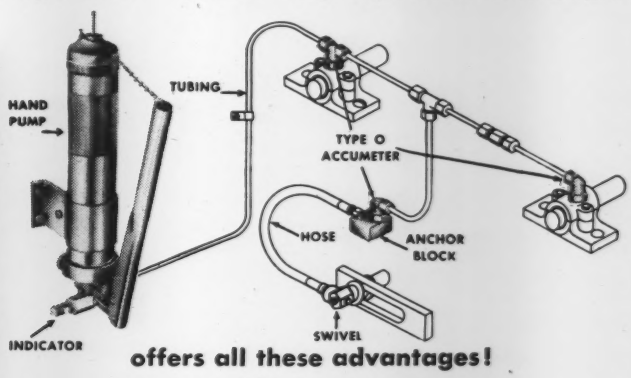
The answer? Alemite Accumeter, the valve that never forgets. This tiny, accurate, and very simple valve automatically meters an *exact* amount of lubricant to the bearing, at exactly the right time, *while the machine is in operation!* Time, maintenance and production costs drop—output soars! That's the reason that better than 95% of all major plants buying machine tools specify centralized lubrication.

Alemite Accumeter Systems are simple and economical to design into any machine—and there is a system perfect for any machine lubrication problem. Find out about these automatic systems now. See for yourself the savings and efficiency they bring to your designs and you too will specify automatic Accumeter.



Type O Accumeter Valves

Meters .005 cubic inch of oil to rotary, oscillating, stationary—plain or anti-friction bearings. Up to 200 small bearings can be served by the single-line system equipped with these fixed output valves. Requires only 5/16" approximate turning radius.



offers all these advantages!

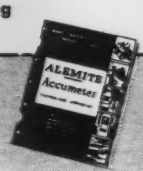
- Eliminates shutdown time for lubrication. Adds productive time to machine output
- Seals completely against dirt, grit, water all the way from "Barrel-to-bearing"
- Prevents bearing troubles due to neglect or use of wrong lubricant
- Services all bearings—including those inaccessible or dangerous—in one operation
- Avoids work spoilage and bearing repairs due to over-lubrication

factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—*equal to* 122 YEARS *of twice-a-day service!*

ALEMITE
REG. U. S. PAT. OFF.

A PRODUCT OF SW STEWART WARNER



Free—*Alemite Accumeter Catalogue*

ALEMITE, DEPT. R-24
1850 Diversey Parkway, Chicago 14, Illinois
Please send me my free copy of the Alemite Accumeter Catalogue

Name.....
Company.....
Address.....
City..... State.....

need information on
transmission equipment?

reach for your Product Design File

"... a great time-saver"

These manufacturers' catalogs are instantly available in Section 3a of your Product Design File:

Airborne Accessories Corp.
Allis-Chalmers Mfg. Co.
American Flexible Coupling Co.
Apex Machine & Tool Co.
Boston Gear Works, Inc.
Cullman Wheel Co.
Dodge Mfg. Corp.
Falk Corporation
Foote Bros. Gear & Mach. Corp.
Industrial Gear Mfg. Co.
Instrument Gear Works
James, D. O.,Gear Mfg. Co.
Link-Belt Company
Lovejoy Flexible Coupling Co.
Morse Chain Company
Raybestos-Manhattan,Inc.
Rockford Clutch Div.
Stearns Magnetic Inc.
Twin Disc Clutch Co.
Warner Elec. Brake & Clutch Co.
Winsmith, Inc.

In other sections of the File you will find additional catalogs containing useful information on product forms, characteristics, performance and use.

Sweet's Catalog Service

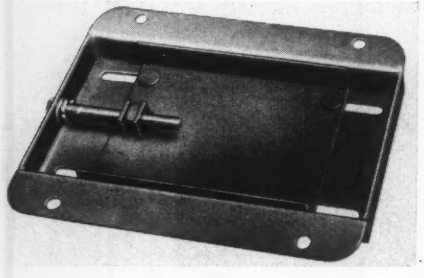
Division of
F. W. Dodge Corporation
119 West 40th Street, New York 18, N. Y.

is 900 psi; modulus of elasticity is 18,000 psi. The filter illustrated employs porous Kel-F filter segments with stainless steel separator rings and is housed in a stainless steel container. It provides one sq ft of filter area in an envelope 5⅜ in. in diameter and 6½ in. long and withstands 75 psi differential across the filter element and up to 1200 psi line pressures. Complete filters are available with from a fraction of a sq ft to 50 sq ft of filter area, and larger units can be made to specification. Made by **Porous Plastic Filter Co.,** Glen Cove, N. Y.

For more data circle MD-84, Page 211

Adjustable Motor Base

Improved model all steel adjustable motor base is designed to fit new sizes of NEMA rerated motors. It is offered assembled with



cadmium plated adjusting screw. Lightweight two-piece base is claimed to be nonbreakable. Made by **Overly-Hautz Co.,** 11500 Madison Ave., Cleveland 2, O.

For more data circle MD-85, Page 211

Magnet Wire

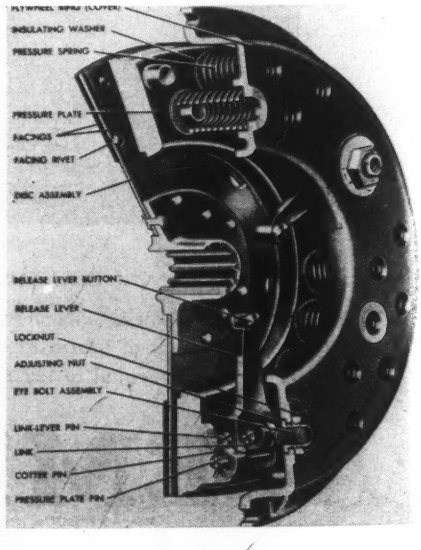
Insulated with Teflon, line of magnet wire is available in wide range of sizes and is designed for class H service or better. Sizes range from 14 to 50 AWG in six colors. Wire has a low loss factor, low dielectric constant and good dielectric strength. Characteristics remain stable at temperatures from −100 C to 260 C. Insulation is nonflammable and is inert to moisture and all commercial solvents and chemicals. Solid conductor can be either annealed or soft copper and single, heavy, triple or quad thicknesses are available. Wire is recommended for high temperature and high frequency applications, especially where miniaturization is a design factor. Made by **Hitemp Wires Inc.,** 26 Windsor Rd., Mineola, L. I., N. Y.

For more data circle MD-86, Page 211

Direct Pressure Clutch

Heavy-duty, nonadjustable DP (direct pressure) clutch which has broad interchangeability with other DP clutches in the field combines high torque capacity, a minimum of parts, low release loads and positive engagement. Clutch has dry-disk push-type construction and will meet around-the-clock service requirements. Regular automotive clutch pedal adjustments are applicable to maintain proper clearance between release bearing and release levers. Located on top and along side walls of clutch cover are 33 ventilating holes.

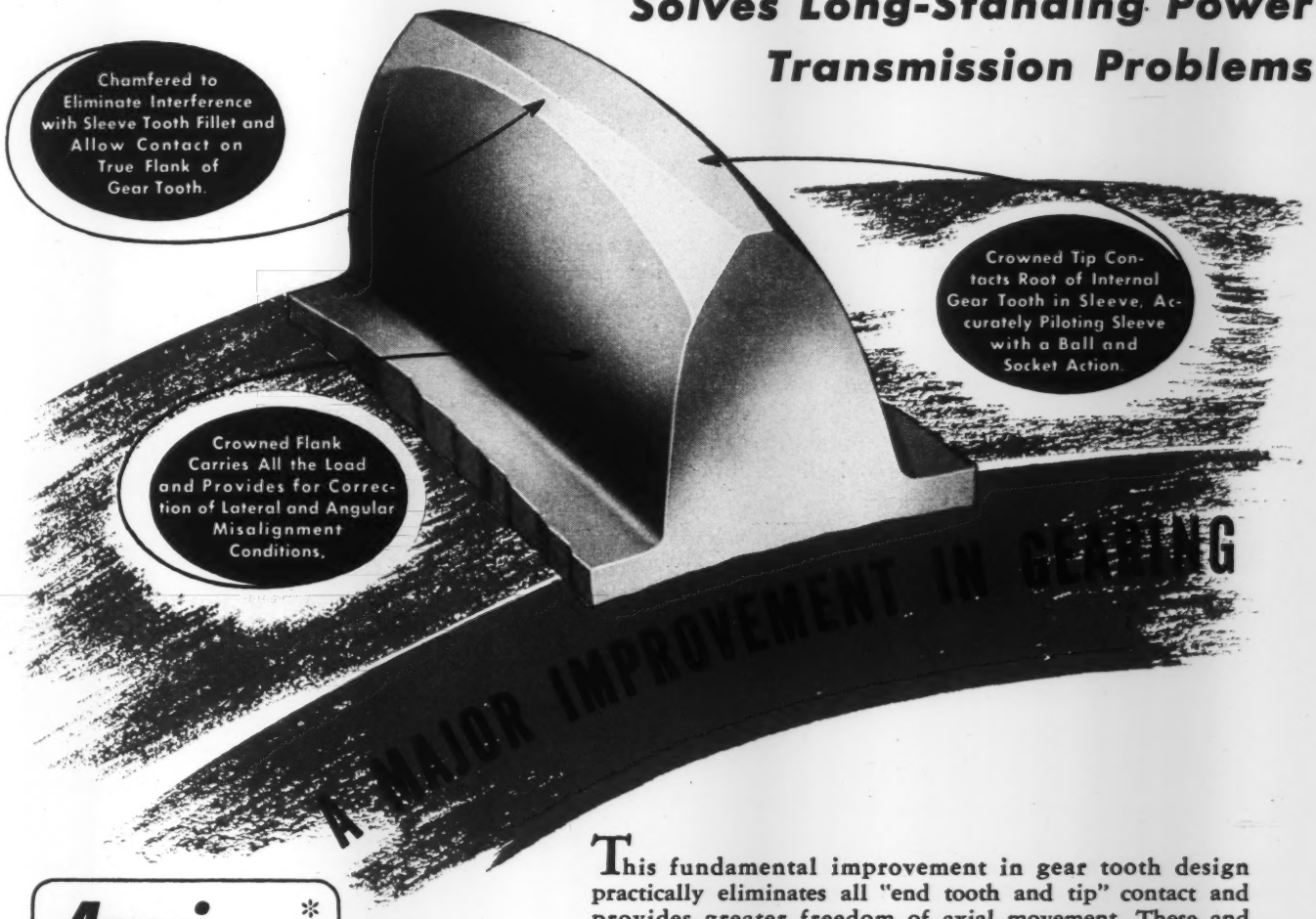
Single plate sizes range from 12 through 15 in., plus a 17-in. size, and double plate models are made in 14 and 15-in. sizes. These sizes will supply ample torque capacities for engines developing 200 to 1400 lb-ft of torque. Various models will accommodate standard flywheels or bell housings, and conventional driven member assemblies with commercial facing ma-



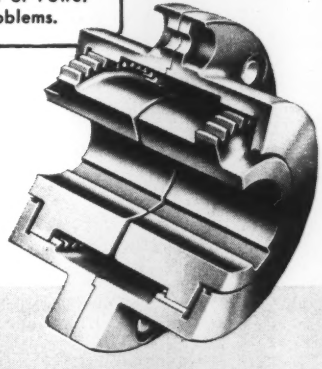
THE Amerigear* ✻ FULLY CROWNED TOOTH DESIGN

*Trade Mark Reg.

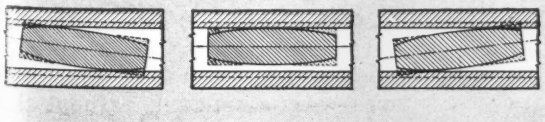
Solves Long-Standing Power Transmission Problems



Amerigear* Fully Crowned Tooth Design Solves Wide Range of Power Transmission Problems.



Oil Seals of Amerigear Couplings Are As Advanced in Design, Performance, and Effectiveness As Is the Amerigear Fully Crowned Tooth.



Comparison of Amerigear Fully Crowned Tooth Design With Gearing of Conventional Gear-Type Couplings Shows How "End Tooth and Tip" Contact Is Practically Eliminated and Why Greater Freedom of Axial Movement Is Provided by Amerigear Fully Crowned Tooth Design (dotted lines indicate gear teeth of conventional gear-type coupling.)

This fundamental improvement in gear tooth design practically eliminates all "end tooth and tip" contact and provides greater freedom of axial movement. These and other exclusive advantages of Amerigear Couplings distinguish them from common gear-type couplings. There are numerous instances where the fully crowned tooth design of Amerigear Couplings has been utilized to simplify power transmission mechanisms and add reliability to performance in a measure heretofore considered impossible.

Amerigear Couplings offer many more advantages than are obtainable with common basic designs. If your problem arises from excessive offset or angular misalignment, tight backlash requirement, space limitations, high speeds and loads, or any combination of these, it can be solved by the use of Amerigear Couplings. Amerigear Engineers are available for consultation.

AMERICAN FLEXIBLE COUPLING COMPANY

ERIE, PA., U. S. A. ***Originator of the Amerigear Fully Crowned Tooth***

Sales Offices in Principal Industrial Centers

In Canada: Canadian Zurn Engineering, Ltd. • 2052 St. Catherine St. W., Montreal 25, P. Q. Canada

American Flexible Coupling Co., Erie, Pa., U. S. A.
Please send me further information regarding AMERIGEAR COUPLINGS with the Fully Crowned Teeth and Catalog No. 501.

Name ..... *Title* .....
Company .....
Address .....
City ..... *State* .....
Please attach to your business letterhead.

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS

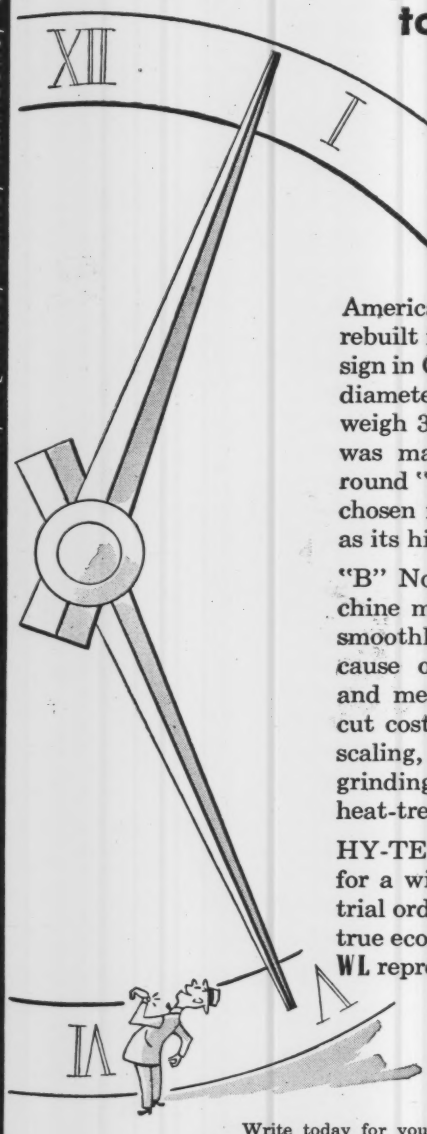
BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS

it's the right time

to Investigate the Qualities of

HY-TEN

ALLOY STEEL



America's largest clock was recently rebuilt for a spectacular illuminated sign in Chicago. It measures 50 ft. in diameter — hands and movement weigh 3000 lbs. The new driveshaft was made from 6 ft. of 3½-inch round "B" No. 3X heat-treated bar, chosen for its machinability as well as its high physical properties.

"B" No. 3X heat-treated bars machine more readily and finish more smoothly than standard alloys because of their particular analysis and method of manufacture. They cut costs by eliminating distortion, scaling, straightening — and often grinding — as well as the cost of heat-treating finished parts.

HY-TEN "B" No. 3X bars are used for a wide range of applications. A trial order will convince you of their true economy. Just call your nearest WL representative.

Write today for your FREE COPIES of Wheelock, Lovejoy Data Sheets, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

WHEELOCK, LOVEJOY & COMPANY, INC.

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CAMBRIDGE • CLEVELAND
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133 Sidney St., Cambridge 39, Mass. and Cleveland • Chicago • Detroit Hillside, N.J. • Buffalo • Cincinnati

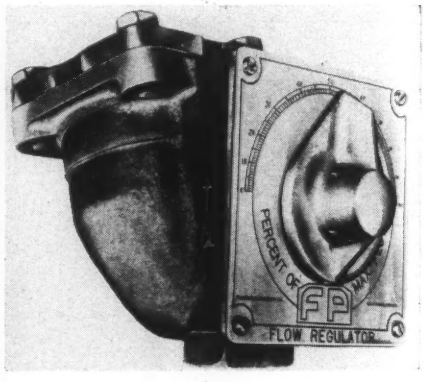
New Parts

terials and spline sizes are available. Made by **Lipe-Rollway Corp.**, 712 Emerson Ave., Syracuse 1, N. Y.

For more data circle MD-87, Page 211

Flow Regulator

Easily maintained self-operated flow regulator can be screwed directly into a pipeline to maintain a preset flow rate in spite of changes in upstream or downstream pressure. It is operated entirely by liquid passing through it. Regulator is adaptable to in-line or panel mounting, as dial and capacity regulating knob are in front, and controller body is rear mounted. Direct manual and remote pneumatic setting arrangements are interchangeable. The ½, 1 and 2-in. sizes can handle flow ranges of 0.5 to 5, 1.0 to 15 and 6 to 80 gpm, respectively. Designed to operate at a pressure loss across the valve of 5 psi, the unit can also be adapted to low-pressure-drop service. Made by **Fischer & Porter Co.**, 17 Jacksonville Rd., Hatboro, Pa.



For more data circle MD-88, Page 211

Plastic-Aluminum Coating

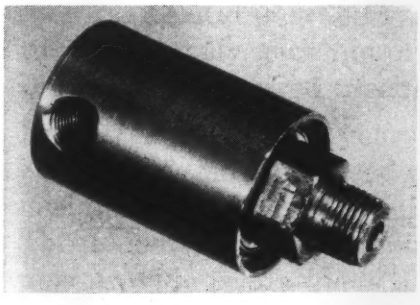
A process for metallizing surfaces with aluminum, without the use of heat, employs Kolmetal, a mixture of finely pulverized aluminum in a plastic base. Two coats of this material air harden to form a plastic bonded aluminum surface which can be polished, ground,

drilled or bent to a 45-degree angle without chipping or cracking. The material also exhibits excellent resistance to atmospheric and sea water corrosion, retains its finish and firm adhesion over a wide temperature range and is inert to many foods, beverages and liquid products. Made by **Emjay Maintenance Engineers,** 327 Union Ave., Rutherford, N. J.

For more data circle MD-89, Page 211

Revolving Joint

Intended for normal temperature applications at air and hydraulic pressures, this high speed revolving joint is usable on air and hydraulic brake and clutch applications. Joint consists of only seven parts and contains a high-speed permanently lubricated bearing. It



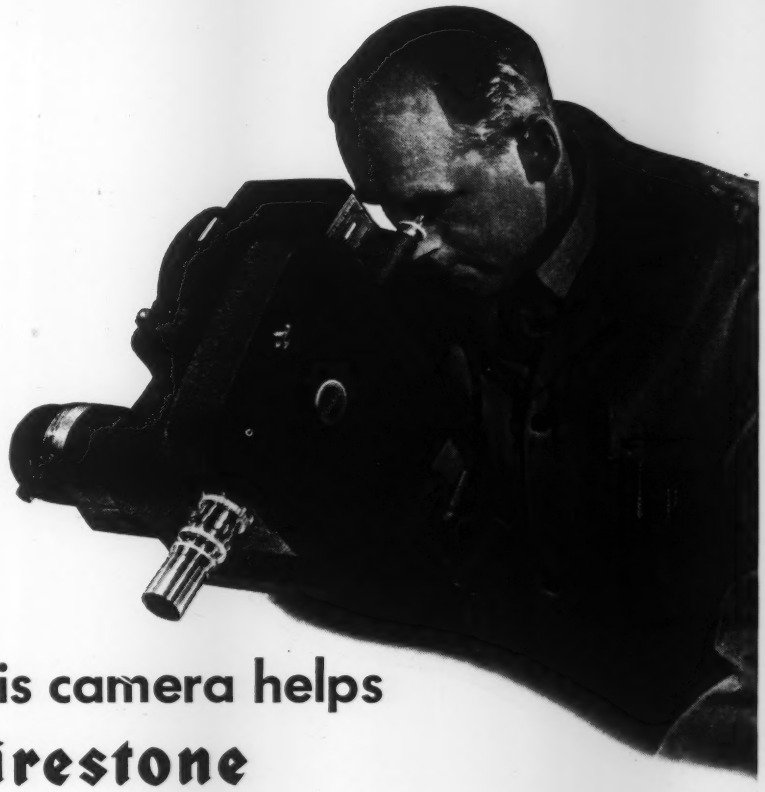
is made in two sizes with ⅛ or ¼-in. threads and has small dimensions and low turning torque. Rotating seal is nonporous heat treated carbon; stationary seal is a standard oil-resistant O-ring. Made by **Rotherm Engineering Co.,** 7280 W. Devon Ave., Chicago 31, Ill.

For more data circle MD-90, Page 211

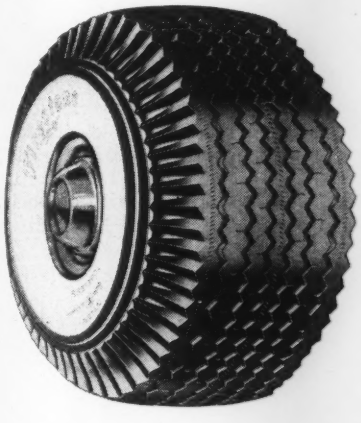
Precut Plastic Labels

Cut-to-size strips or labels of self-adhesive plastic "write on it" tape are available to specification in 1 to 6-in. lengths and 5/16 to 3-in. widths. Any of a variety of border colors can be specified. Any dry blunt point such as pencil or stylus can be used to write on labels. Legend is protected by

(*Continued on Page* 230)



This camera helps
Firestone
make a safer tire



What happens when a tire runs over a stone at high speed? That's a hard question to answer, since the action is too fast to see.

Firestone Tire & Rubber Company engineers help answer such questions with a Kodak High Speed Camera. With it they are able to study and analyze the high-speed action of tires at the moment of shock, do basic research on the elusive elastic properties of rubber.

The Kodak High Speed Camera takes up to 3200 pictures a second on 16mm film. Showing the films at normal speeds on a standard projector slows action as much as 200 times. For detailed study, film may be run over and over, stopped at important frames. A built-in argon lamp makes accurate timing checks possible.

If high-speed action is hiding the solution to your design or performance problem, you should investigate the Kodak High Speed Camera. You'll find its ease of operation and speed range make it particularly suited to industrial applications. To see how it has worked for others, send for a copy of the booklet, "High Speed Motion Picture Taking In Industry." Or write for details on a sound movie, "Magnifying Time."

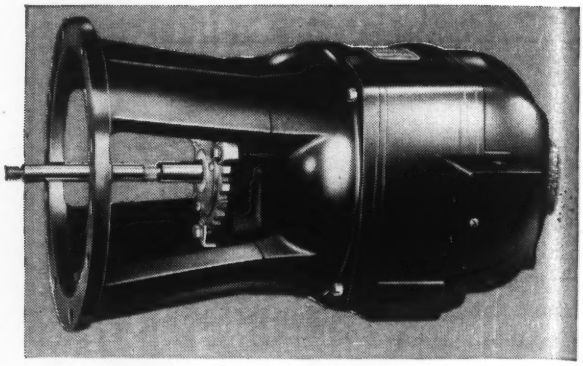
the Kodak
HIGH SPEED
Camera

Industrial Photographic Division
EASTMAN KODAK COMPANY
Rochester 4, N. Y.

Kodak

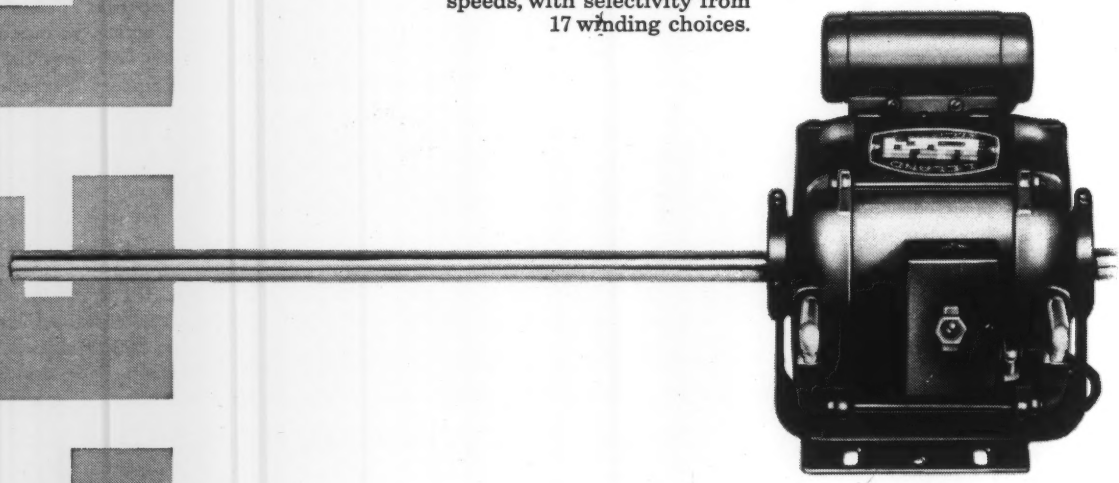
LELAND

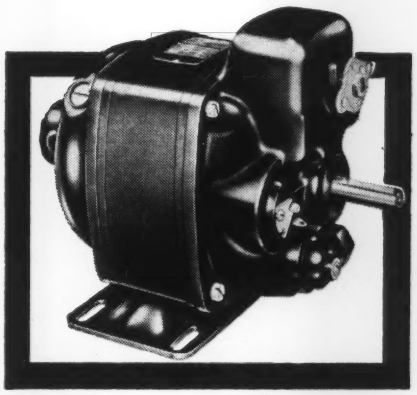
Unique Leland motor, designed to mate precisely with vacuum pump, provides micrometer axial shaft positioning and pump impellor adjustment.



LELAND'S Creative is more than

Year-round "thermal conditioning" in an unusual ventilating unit is quiet and comfortable, thanks to the enclosed, efficient Leland motor power. Special extended blower shafts turn at high or low speeds, with selectivity from 17 winding choices.





The Leland-developed explosion-proof motor that for 30 years has outsold all other makes combined for powering gasoline curb pumps.

Electrical Engineering a phrase!

Leland's whole organization is particularly geared to serve the needs of the Original Equipment Manufacturer. When his exact requirements cannot be filled by one of the many *standard* types of Leland motors, Leland engineers *welcome* the opportunity to work closely with his products' engineers to provide the required mechanical or electrical design.

During more than 30 years, Leland's *creative electrical engineering* has produced hundreds of special motor designs . . . each ideally suited to a specific application. These designs, carefully filed for quick reference, now provide ready-made answers to many current application problems, often enabling Leland to fill special motor requirements with maximum speed and economy.

Leland's representatives are graduate engineers, thoroughly qualified to grasp and discuss your motor needs. If these needs fall within the 1/6 to 5 HP range, you'll do well to contact your local Leland representative . . . or write or phone direct to—

Special features of this Leland food machinery motor design include interchangeable mounting for ¾, 1 or 1½ HP, single phase or three phase.

The LELAND ELECTRIC Co.

DAYTON 1, OHIO

Division of AMERICAN MACHINE & FOUNDRY COMPANY, New York

In CANADA, Leland Electric Canada, Ltd., Guelph, Ontario

AMF products are better . . . *by design*

(Advertisement)

"An Opportunity FOR Professional Growth without Parallel"

Fairchild, one of America's leading manufacturers of aerial cameras, graphic arts equipment, and precision instruments, has openings in its Engineering Department for several high calibre engineers with special qualifications. The positions open will satisfy both the inventor, who likes to work alone and the extrovert who does best when supervising and working with others. Starting salaries are high and increases are made periodically based on merit and initiative.

PRODUCT DESIGN LEADER

This is our title for the highest design engineering job at Fairchild. You may presently have a title such as Chief Draftsman, Chief Mechanical Engineer, Chief Designer, etc., but if the described requirements fit, you too may become one of the elite who hold the title of Product Design Leader. The individual we want is an outstanding creative and inventive engineer capable of heading projects in a laboratory but whose experience permits, and desire is, to work from the drafting board. He should be a graduate mechanical engineer or equivalent with about 12 years' experience in development and design of which about 3 years should be in design supervisory capacity; capable of the original design of intricate, precise electro-mechanical and optical instruments; a man with a record of inventive and creative accomplishments; able to supervise the design of subordinate Product Designers and Design Engineers; and coordinate with Program Chiefs, Project Engineers and the Experimental Machine Shop. He will have a wide latitude for independent action. Familiarity with military specifications and requirements is desirable but not essential. This is a top level position, as revealed by the salary and duties, and is not to be confused with that of the usual design engineering.

PRODUCT DESIGNERS

This position is also of high level requiring professional skill and creative thinking. The individual we want is an inventor and an originator of new ideas capable of producing sound solutions to intricate problems. Although this man may be working at a desk or in the laboratory, he shall have a keen desire to return to the drafting board to satisfy his creating ambition. He should be a graduate mechanical engineer or equivalent with about 10 years' experience in development and design; capable of originating the designs of intricate, precise electro-mechanical and optical instruments; and a man with a record of inventive and creative accomplishments. He will have a wide latitude for independent action. Familiarity with military specifications and requirements is desirable but not essential. The salary is high commensurate with these requirements.

Call in person, phone, or send complete resume to
MR. JOHN McCAULEY
23 West John St., Hicksville, L. I.
stating experience, education, salary required and date available.

FAIRCHILD
CAMERA AND INSTRUMENT CORPORATION
Hicksville, L. I. Hicksville 3-4500

New Parts

(*Continued from Page 227*)

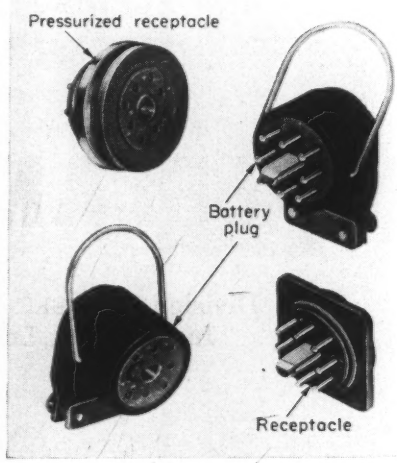
transparent plastic outer layer against smudging, dirt, oil, water and most acids and chemicals. Tape resists temperatures from −40 to 150 F, will not curl or discolor with age and retain their adhesive quality after numerous reapplications.

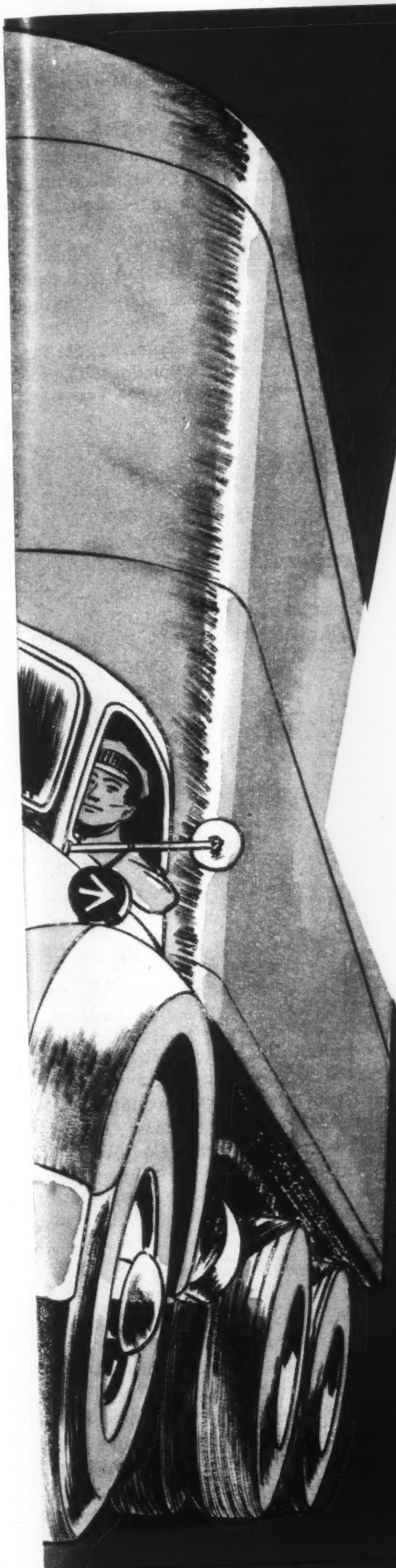
Strips are mounted on a polyethylene paper from which they peel cleanly. Made by **Labelon Tape Co. Inc.**, 450 Atlantic Ave., Rochester 9, N. Y.

For more data circle MD-91, Page 211

Center Polarized Connectors

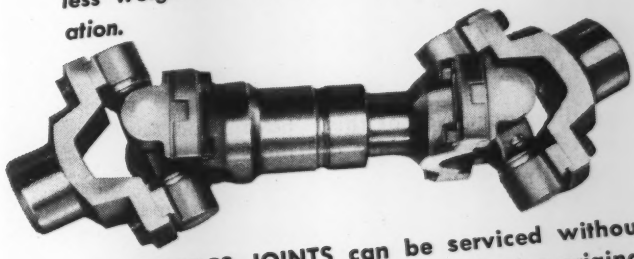
Two new types of mating receptacles and plugs have center polarized pins and sockets. Both have eight contacts. No. 2411 receptacle, pressurized to withstand 5 psi, is 1 5/8 in. in diameter by 7/8-in. thick and is designed for panel mounting with spanner ring. No. 2412 receptacle has a square flange for panel mounting; center-to-center mounting hole dimensions are 1 1/16 in.; and overall thickness is 3/8-in. It is unpressurized and has





More Profit Time with Less Down Time

MECHANICS Roller Bearing UNIVERSAL JOINTS will give *your trucks more road time and less shop time* because MECHANICS JOINTS are specially designed with less parts and connections — for *easy assembly and servicing — smooth running balance — maximum strength with less weight* — and *long, trouble-free, safe operation.*



MECHANICS JOINTS can be serviced without disturbing other attachments or altering original propeller shaft balance. Let MECHANICS engineers give *your trucks* or heavy duty machines these competitive advantages.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner
2032 HARRISON AVE. ROCKFORD, ILLINOIS

MECHANICS
Roller Bearing
UNIVERSAL JOINTS

For Cars, Trucks, Tractors, Farm Implements, Road Machinery, Industrial Equipment, Aircraft

Cramer TIMERS CONTROL

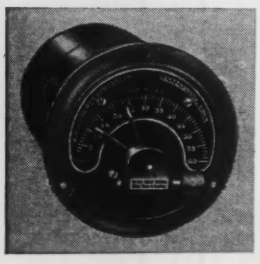
precise roll threading operations

The threading accuracy of this Steinle Roll Threading Machine is directly related to the highly dependable Cramer Timers which govern the roll slide movements. This carefully predetermined slide travel must be extremely accurate in order to insure thread precision and uniformity.

The Cramer TE Timer, at left, controls the time of dwell of the roll slide in its forward position, while the one at right dictates the exact loading interval. A simple adjustment of either timer permits slow-down or speed-up of the action. Cramer-controlled threading operations on the Steinle machine have been speeded to 40 complete cycles per minute without sacrifice of thread accuracy. There has never been a report of timer failure.

The Steinle Machine is widely used by aircraft manufacturers and others who require extremely accurate threads. Cramer Timers are specified as original equipment for these machines due to their unusually high standards of accuracy and dependability.

If you have a time control problem, Cramer can help you. Write for complete information or technical advice.



The overall accuracy of the Type TE (inclusive of setting) is within 2%, with repeat accuracy within ½ of 1%. The unit is Underwriters' Laboratories listed for use in industrial control equipment.

SPECIALISTS IN TIME CONTROL

Cramer TIMING DEVICES

BOX 6, CENTERBROOK, CONNECTICUT

2CR54

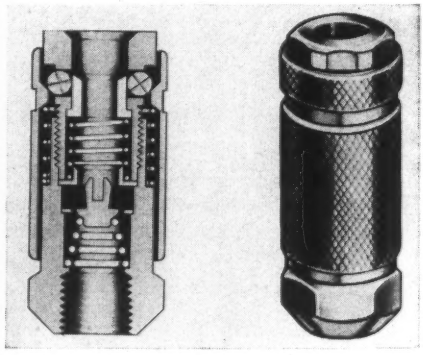
New Parts

Teflon rear insulator. Mating plugs for both receptacles have hoods with pull rings and right angle cable clamps. Receptacle shells are aluminum with gray anodized finish, inserts are molded phenolic, and contacts are beryllium copper with silver plating. Plugs are aluminum with black anodized finish, and pins are brass with silver plating. Units are designed for 135 v, dc service. Made by **H. H. Buggie Inc.**, 726 Stanton St., Toledo 4, O.

For more data circle MD-92, Page 211

Quick Air Coupler

Permitting air flow of 70 cfm at 150 psi, Quick-Detachable air coupler is compact and weighs 4½ oz. Coupling and uncoupling is instantaneous with one push or pull, yet unit cannot be detached



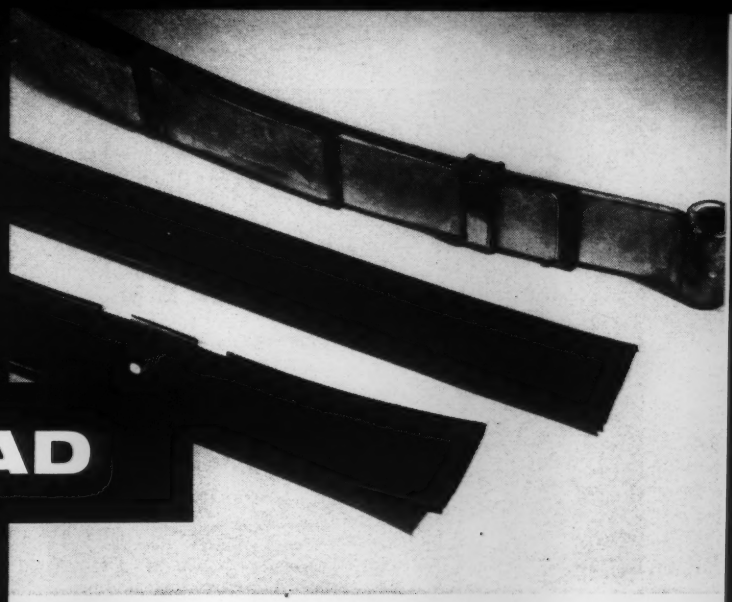
accidentally. When unit is detached from nipple, flow of air is shut off instantly. Free-swiveling action prevents kinking of hose. Made by **Lincoln Engineering Co.**, 5701 Natural Bridge Ave., St. Louis 20, Mo.

For more data circle MD-93, Page 211

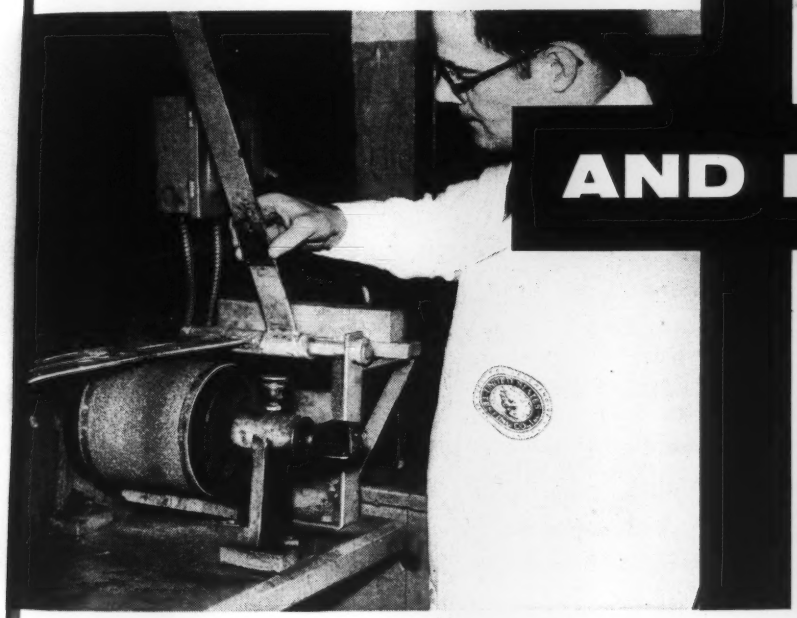
Fan-Cooled Motor

High-velocity internal cooling fan incorporated in line of 15 through 30-hp motors provides sufficient cooling capacity to permit higher horsepower ratings to be obtained from smaller frame sizes. Illustrated 30-hp unit, which ordinarily requires No. 365 frame, is built into No. 326 frame. Fan measuring 13-in. diameter by 5⅞ in. wide is mounted on motor shaft

tested



ON THE ROAD



AND IN THE LAB

Here's double proof of BAKELITE Polyethylene's *wear resistance*

On the Road—BAKELITE Polyethylene proves its outstanding wear resistance when molded into automobile leaf spring liners. These "dry lubricants" fit tightly between the leaves, preventing squeaks caused by metal-to-metal contact. Their waxy surface is unaffected by hot or cold weather. Their molded flanges hold the leaves in line and seal out grit that can cause spring breakdown. These liners won't absorb moisture, and are unaffected by salt and other snow-melting chemicals.

In the Lab—the wear resistance of BAKELITE Polyethylene is shown by tests described in a report by the U. S. Testing Co., dated Sept. 24, 1953. In comparison with a well-known rubber-type compound, BAKELITE Polyethylene was tested by rubbing it against various surfaces with a rotary motion, a reciprocating motion, and a combination of both. The abrading agents were "Aloxite" 320 metal cloth, cold-rolled steel, and maple wood.

Conclusion stated that BAKELITE Polyethylene possessed "superior abrasion resistance." In one test, involving rotary motion, and employing "Aloxite" 320 as the abrading agent, BAKELITE Polyethylene lost 40 to 45 per cent of its thickness in 2000 revolutions, while the rubber-type compound lost 75 to 80 per cent in 280 revolutions.

Such evidence of the toughness and wear resistance inherent in BAKELITE Polyethylene indicates increased use of this material for molding and extrusion applications where service conditions will be severe. Complete details on the abrasion resistance tests are given in KABELITEMS No. 68. For your free copy, write Dept. TJ-52.

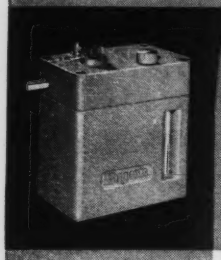
BAKELITE
TRADE-MARK
Polyethylene

BAKELITE COMPANY

A Division of Union Carbide and Carbon Corporation UCC
30 East 42nd Street, New York 17, New York

In Canada: Bakelite Company
A Division of Union Carbide Canada Limited
Belleville, Ontario

"STANDARD EQUIPMENT"



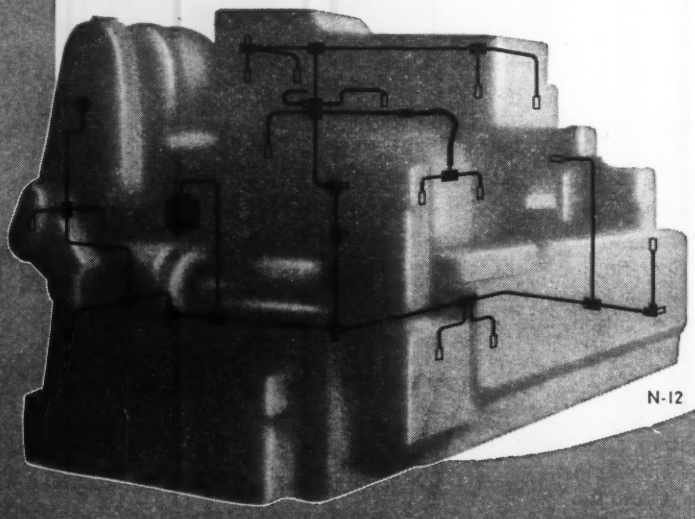
where the BEST is Demanded!

America's leading machine builders *standardize* on Bijur Automatic Lubricating Systems to provide the *best in bearing protection.*

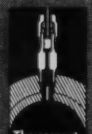
Bijur guards against bearing failure . . . lubricates with the *right amount* of oil at the *right time.*

Specify Bijur on machines now in production or in the planning stage. Assure increased production . . . higher speeds . . . smoother operation and longer machine life.

For recommendations, call in the Bijur engineer.



N-12

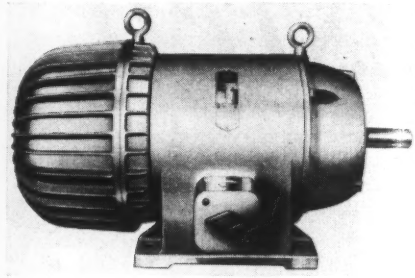


The correct oil film to each individual bearing... automatically

BIJUR LUBRICATING CORPORATION
Rochelle Park, New Jersey

176

New Parts



and is housed within fin-type endbell. All units feature dripproof construction and can be furnished with either single-end shaft or hydraulic pump mount endbells. Made by **Reuland Electric Co.,** 3001 West Mission Rd., Alhambra, Calif.

For more data circle MD-94, Page 211

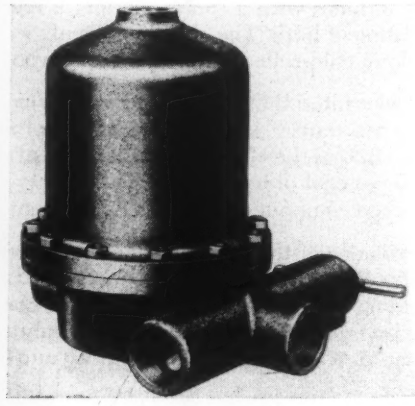
Plastic Pipe

Pipe made from B. F. Goodrich Chemical Co. polyvinyl chloride resin plastic weighs only one-fifth as much as steel pipe of the same size. It is resistant to corrosion caused by alkalies and acids and has high impact strength. Slip-sleeve fittings are attached to the pipe with a solvent cement which is applied by brush, the resulting connections being as strong as any other part of the pipe. Made by **Alpha Plastics Inc.,** West Orange, N. J.

For more data circle MD-95, Page 211

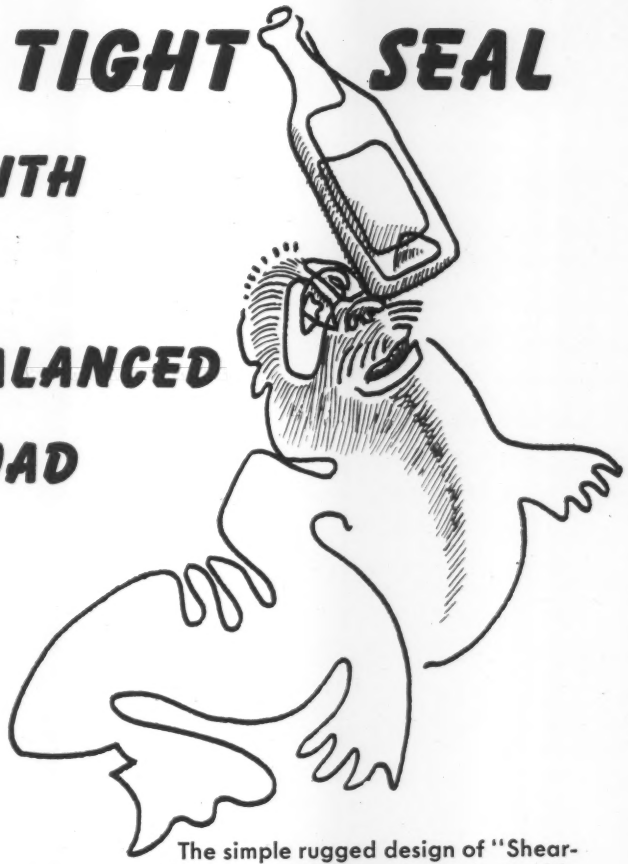
Reverse Flushing Filters

All suspended foreign matter is removed from liquids passing the all-bronze Por-O-Met reverse flush-



(Advertisement)

A TIGHT SEAL WITH A BALANCED LOAD



The simple rugged design of "Shear-Seal" valves pays off in an unbelievably *long service life free from maintenance* of any kind.

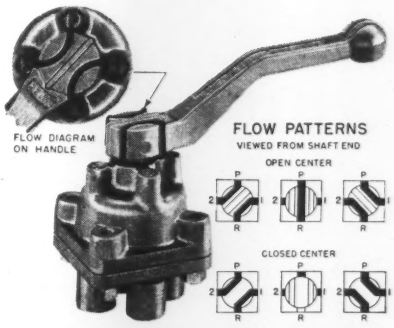
The *leakproof* closure of the self aligning, self cleaning valving members actually improves with the lapping action of each operation; they wear-in, where others wear-out.

They are not put out of commission by dirt or erosion (wire drawing), because *flow is through, never across, sealing members.*

"Shear-Seal" valves provide excellent *throttling* action, *never freeze up*, and *without lubrication* or constant servicing of any kind.

The 4-way selector valve for 1500 p.s.i. oil service, illustrated below, has been developed with particular consideration of the *Original Equipment Manufacturer.*

Worthwhile savings, in first and after costs, are passed on through *latest manufacturing methods*, through design features with unusual *versatility* in mounting and piping arrangement, through an unmatched *trouble-free service life.*



BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, Calif.

FREE USEFUL LITERATURE

Pressure Switch Selection Chart provides an easy method of finding a pressure switch for your specific application. This tabulation helps you define your requirements and saves you time in finding the correct switch for your job.

Check number M3 on the coupon below.

Piston Pressure Switch bulletin describes in detail the entire service range from 15 to 3000 P.S.I. (7000 P.S.I. proof pressure). Belongs on Production Equipment, where millions of cycles are expected, and on Original Equipment, where flexibility and price are a factor.

Check number 9612 on the coupon below.

Variable Actuation Valve Switch is outlined in this bulletin. They are bourdon tube switches with proof pressures to 12,000 P.S.I.

Check number 314 on coupon below.

The "Shear-Seal" principle is a revolutionary twentieth century advancement in valving extreme pressures as well as low pressures and vacuum. The only known method to achieve leakproof closure and maintain or improve sealing qualities with use. This patented principle is illustrated and discussed in a comprehensive bulletin.

Check number BV-2 on the coupon below.

Solenoid "Shear-Seal" Valve Catalog gives complete information on line of shut-off, diverter, 3-way and 4-way selector and 3 position selector valves for Air, Water and Oil Service to 3000 P.S.I.

Check number 1B-2 on coupon below.

Solenoid Air Valves, the famous Crescent 3-way and 4-way valves, are catalogued with complete technical description in this eight-page brochure. Where long service without valve maintenance or solenoid trouble is essential, these valves have become standard.

Check number 3C-1 on the coupon below.

New 20-page catalog includes all basic information on Barksdale Manual Shear-Seal valves, Solenoid Shear-Seal valves, Meletron Pressure Switches, and Crescent Air Valves.

Check number 3G on coupon below.

Barksdale Valves

5125 Alcoa Ave. L.A. 58, Calif.

M3 ☐ 9612 ☐ 314 ☐ BV-2 ☐

1B-2 ☐ 3C-1 ☐ 3G ☐

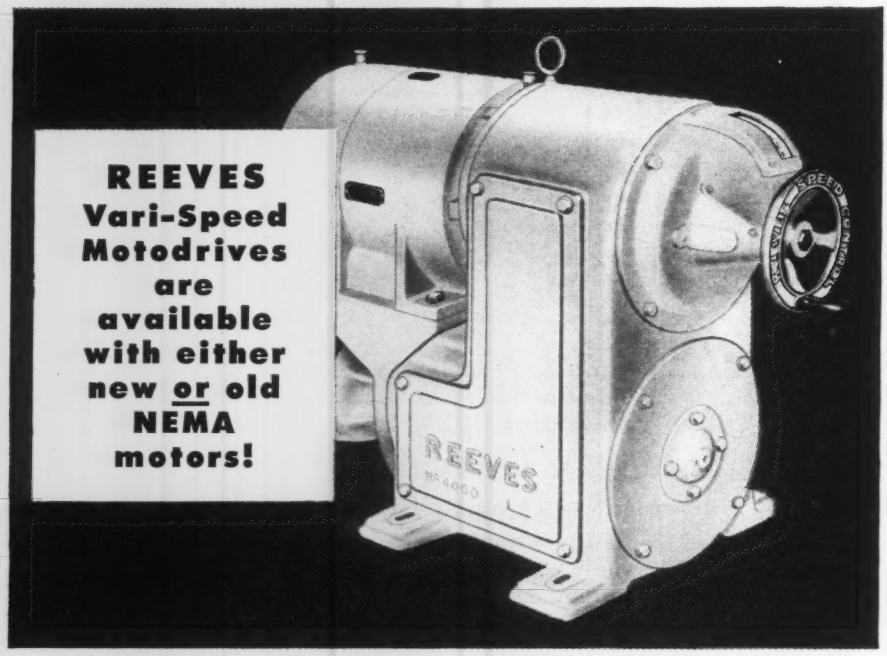
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Choose New or Old NEMA Motors



. . . but always choose

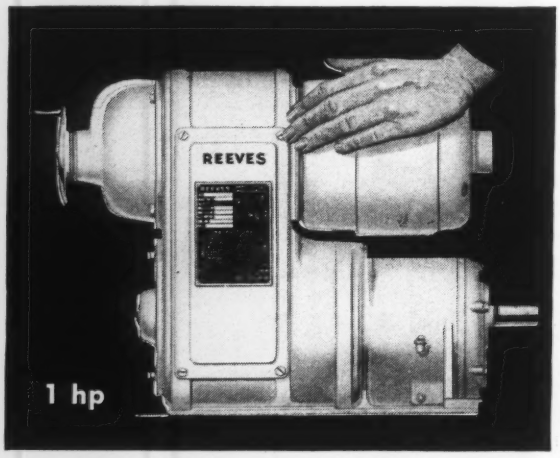
REEVES

With each new development and improvement in industrial progress—such as the new, smaller size NEMA Motors—you can always look to REEVES to be in step with the latest, most modern developments in speed control. You don't have to wait for new designs or adaptations. In keeping with their fine pioneer tradition, REEVES offers you *now* all the advantages of *smaller* Motodrives in practically every case when you order 1 hp or 2 hp drives with the new NEMA Motors. Write today for complete details to Dept. H5-3N.

Smaller MOTORS . . .

Smaller MOTODRIVES!

for 1 hp or 2 hp with new frame NEMA motors



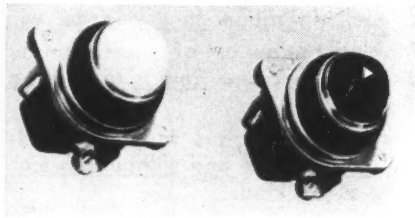
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

ing filters. Models H for 1-in. pipe connection and K for 2-in. connection have lifetime filter elements made of sintered bronze, microporous porcelain (ceramic) or porous Alundum, each available in a range of grade sizes for removing particles of 100 microns down to 0.5-micron. Removal of collected foreign matter is accomplished without disassembly by reverse flushing, effected by push-pull of a plunger. Steam, air or other liquid can be used for reverse flushing when required. Made by **Homefiltr Co.,** North Brookfield, Mass.

For more data circle MD-96, Page 211

Oiltight Indicating Lights

Heavy-duty oiltight indicating lights have all-glass faceted lenses, are factory sealed to metal caps and have all-angle visibility. They are available with red, green, white, blue, amber and clear glass and are designed for both front



and back mounting. Available in three forms—resistor, transformer and full-voltage, they are rated from 110 to 600 volts with a 10-amp continuous rating. Made by **General Electric Co.,** General Purpose Control Dept., Schenectady 5, N. Y.

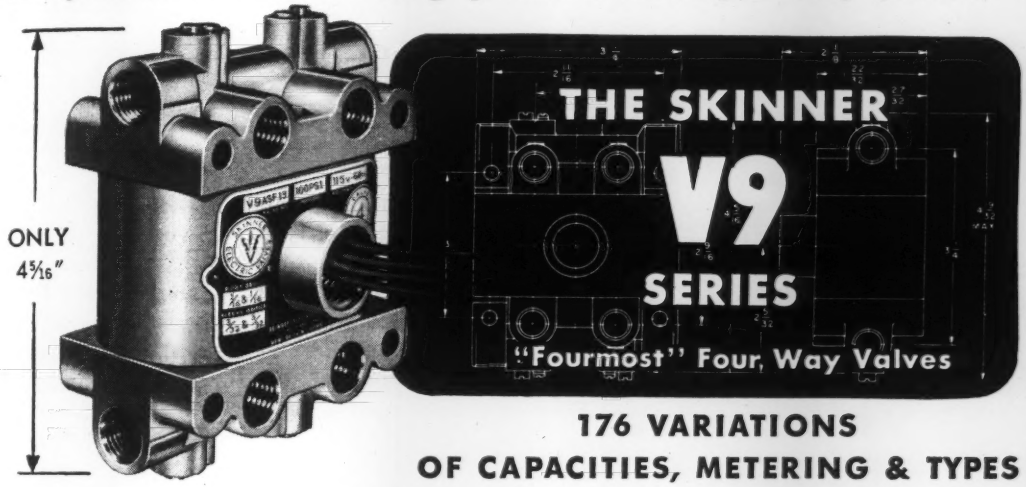
For more data circle MD-97, Page 211

Molded Oil Seals

Molded LPD Clipper shaft oil seals require little lubrication. Seal lip contacts shaft in a thin line round its circumference, resulting in minimum seal wear and low frictional heat and drag. It is retained both by large hinge area and a garter spring, enabling it to accommodate minor shaft run-

SKINNER INTRODUCES
A NEW SMALLER FOUR-WAY
SOLENOID VALVE

for operation of a double-acting cylinder or two single-acting cylinders



176 VARIATIONS OF CAPACITIES, METERING & TYPES

The V9 is offered in 3 basic types: normally closed, normally open, or combination — normally open and normally closed.

Pressures range from 50 to 150 p.s.i. With orifices from 3/64" to 1/8" dia., V9 models have an exceptionally wide range of port locations and metering flow adjustments for Speed Control.

This series meets Skinner's highest traditions of quality. V9 construction is packless, frictionless; there are no troublesome sliding seals or close fits. Bodies are die-cast zinc; internal parts are made of stainless steel. Steel coil housing has zinc chromate finish. Coils are moisture-resistant, varnish-impregnated; molded "waterproof" coils available on request.

LEAKPROOF
Bubble-tight shut-off at all ports

FAST OPERATING
Up to 6 hundred cycles per minute

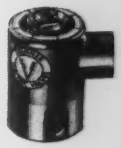
DIRECT ACTING
Positive spring-loaded operation — *NO* sliding seals, will operate in any position

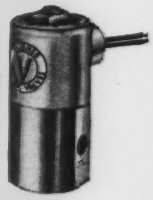
DEPENDABLE
Millions of cycles on most applications — without maintenance

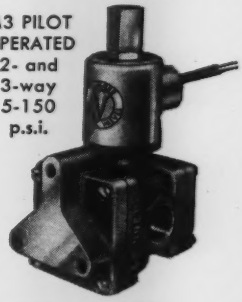
GENERAL SPECIFICATIONS

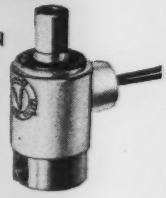
MEDIA.....Air, hydraulic oils, and other common media
PIPE SIZE.....All pipe connections 1/4" NPT
ELECTRICAL OUTLET.....1/2" NPT Conduit
DUTY CYCLE.....Continuous
VOLTAGE.....All common AC and DC voltages
POWER CONSUMPTION.....Per Coil — 10 watts
Both Coils — 20 watts max.
TEMPERATURE..... Minus 65°F. to Plus 150°F.

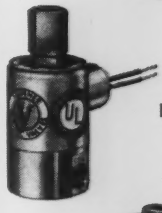
Modern production equipment and methods assure immediate delivery on stock valves, and highest quality standards. Valves are guaranteed for 1 year against defects in materials or workmanship.

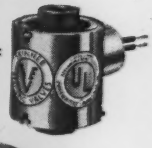

V5-2 SHUT-OFF 2-way 0-1000 p.s.i.

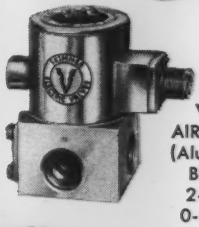

V10 HYDRAULIC 3-way 0-1000 p.s.i.


M3 PILOT OPERATED 2- and 3-way 5-150 p.s.i.


X5 EXPLOSION PROOF (V5 type) 2- and 3-way 0-1000 p.s.i.


V5-3 QUICK EXHAUST 3-way 0-150 p.s.i.

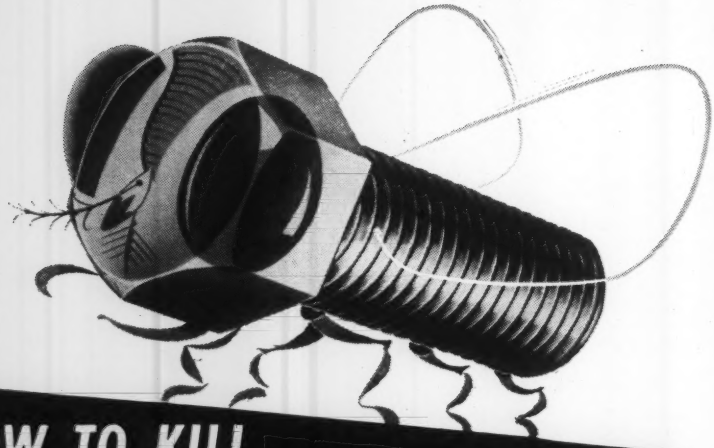

V2 SHUT-OFF 2-way 0-200 p.s.i.


V50 AIRCRAFT (Aluminum Body) 2-way 0-3000 p.s.i.

For detailed specifications write for Bulletin **No. 532**

SKINNER ELECTRIC VALVES® SOLENOID VALVES

SKINNER ELECTRIC VALVE DIV., The Skinner Chuck Company, 115 Edgewood Ave., New Britain, Connecticut



HOW TO KILL
5 thread fastening bugs in design...

Been Stung BY TOO MUCH WEIGHT? ***Heli-Coil**** Inserts permit weight reduction two ways: They require less space than solid bushings. Need no greater boss radius than unprotected thread assemblies. Permit the use of fewer, smaller, shorter threaded fasteners.

Been Stung BY WEAK THREADS? ***Heli-Coil*** Inserts provide a minimum of 25% greater loading strength than unprotected threads in the same material. You eliminate stripping, even in soft materials such as aluminum, magnesium, plastics, wood, etc.

Been Stung BY THREAD WEAR? ***Heli-Coil*** Inserts can't wear — therefore no customer complaints about worn threads; field service costs are cut.

Been Stung BY CORROSION? ***Heli-Coil*** Inserts are corrosion-proof stainless steel or phosphor bronze. They withstand temperatures up to 800°F. indefinitely — won't seize, gall or corrode.

Been Stung BY VIBRATION? Vibration will not loosen ***Heli-Coil*** Inserts; will not damage insert-protected threads. Fits are inherently better; stresses are more evenly distributed.

When you use *Heli-Coil* Screw Thread Inserts you kill *all five* of these design bugs *at once*.

To find out ***why*** the ***Heli-Coil*** Insert method of thread protection is the simplest, most effective, and most practical . . . to get all the data you need to design these advantages into your product . . . to get free samples of ***Heli-Coil*** Inserts, use this handy coupon.

*Reg. U. S. Pat. Off.

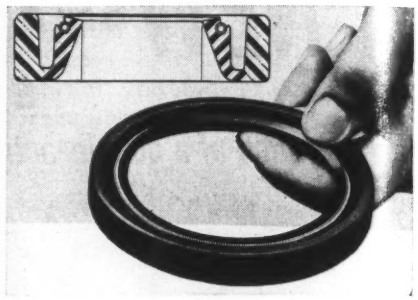
HELI-COIL CORPORATION
122 SHELTER ROCK LANE, DANBURY, CONN.

☐ Send samples and Bulletin 689 — Military Standard Sheets.
☐ Please have a *Heli-Coil* Thread Engineer call.
☐ Send samples and Handbook 652, a complete design manual.

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 2654

***Heli-Coil* Inserts conform to official military standards MS-122076 (ASG) through MS-124850 (ASG) and others.**

New Parts



out and eccentricities. Seals have composition heel which is a press fit in the bearing cavity and readily conforms to slight irregularities in this cavity. They can be removed and replaced without damage. Reinforced heels and different compositions are available for wide range of service conditions and temperatures. Made by **Johns-Manville,** 22 East 40th St., New York 16, N. Y.

For more data circle MD-98, Page 211

Spring Alloy

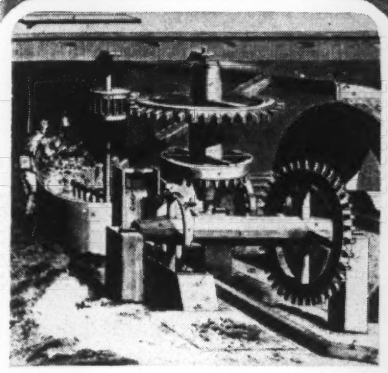
Developed originally for watch mainsprings, Elgiloy is available for general industrial use. This material is highly corrosion and fatigue-resistant. It is also highly elastic, has high tensile strength and can be soldered, welded, brazed, punched or formed. It is used as a spring material and for flapper valves and diaphragms. Made by **Elgin National Watch Co.,** Abrasives Div., Elgin, Ill.

For more data circle MD-99, Page 211

Silencers

Two series of exhaust silencers quiet noise caused by the expulsion of high velocity air to the atmosphere by air compressors,

blowers, vacuum pumps and other machines. The silencers are designed for operation under mois-



Courtesy The Bettmann Archive

Recognize it?

The "Goldberg" above is an example of 17th century power transmission . . . wooden gears and all. Modern power transmission has come a long, long way since then . . . to advanced ideas like shaft-mounting and flame-hardened gears in the American Shaft-King. When the *next* revolution in design takes place, look at the nameplate on the casing . . . it too will say "American Pulley".

Try a new approach to your selection of a Speed Reducer

Have you trouble deciding which of the many makes of Speed-Reduction Drives you should use?

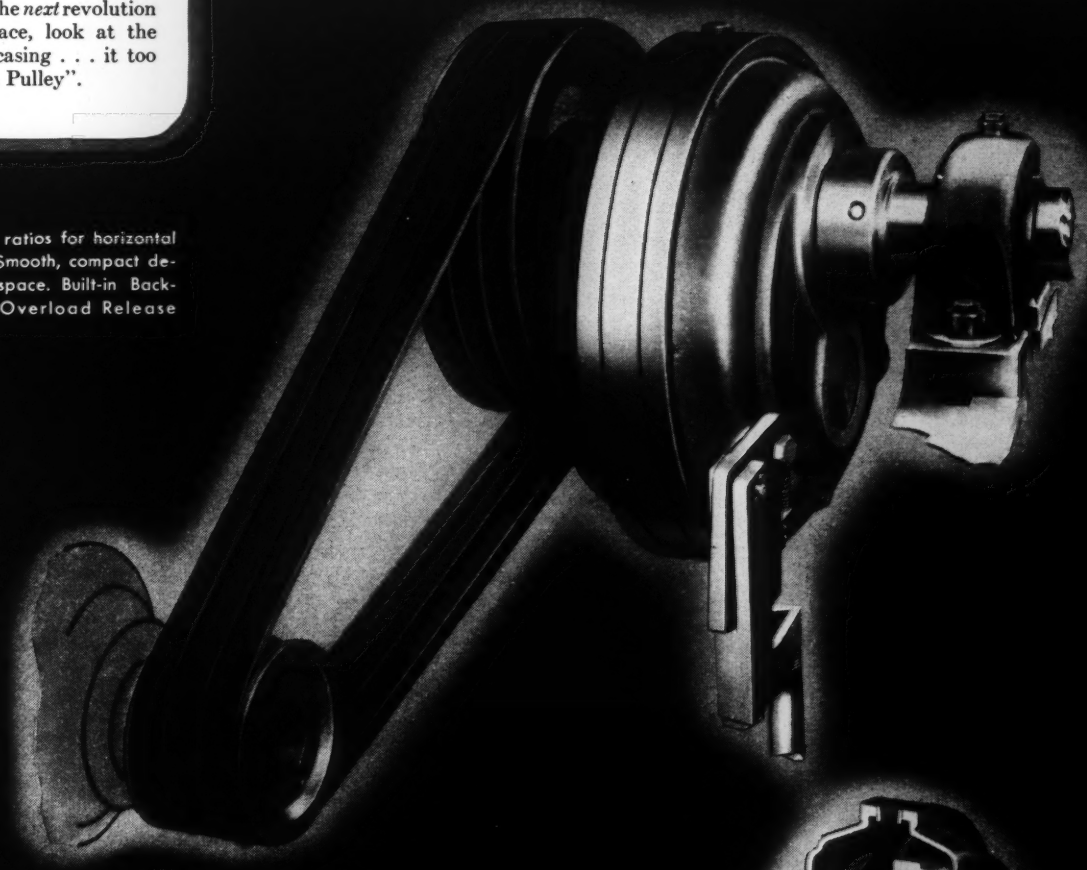
Try a new answer—the Shaft-King, product of The American Pulley Company.

The Shaft-King isn't the traditional type of speed reducer; it's an entirely different idea in speed reducer design. We started by throwing the book out the window; then we applied fresh thinking to every one of its parts.

The result is a speed reducer requiring no floor space, and no foundations or supports—because it mounts directly on the shaft of the driven machine; no special engineering; no special anything to install.

Complete Shaft-King Reduction Drives can be purchased out of factory stock and from the shelves of your local distributor. It's as simple as that. When you call or write for information, ask about these American Pulley products also: Backstops; Overload Releases; and Wedgbelt Econ-O-Matic Drives. The American Pulley Company 4236 Wissahickon Ave., Phila. 29, Pa.

Made in 13:1 and 20:1 ratios for horizontal and vertical mounting. Smooth, compact design sheds dirt, saves space. Built-in Backstop and Automatic Overload Release available as extras.



Interchangeable bushings for easy installation • Flame-hardened alloy steel gearing • Anti-friction, leak-proof sealing system • Patented, concentric-shaft design places oil level below shaft seals • Rigid 3-wall housing keeps gears and bearings in permanent alignment.

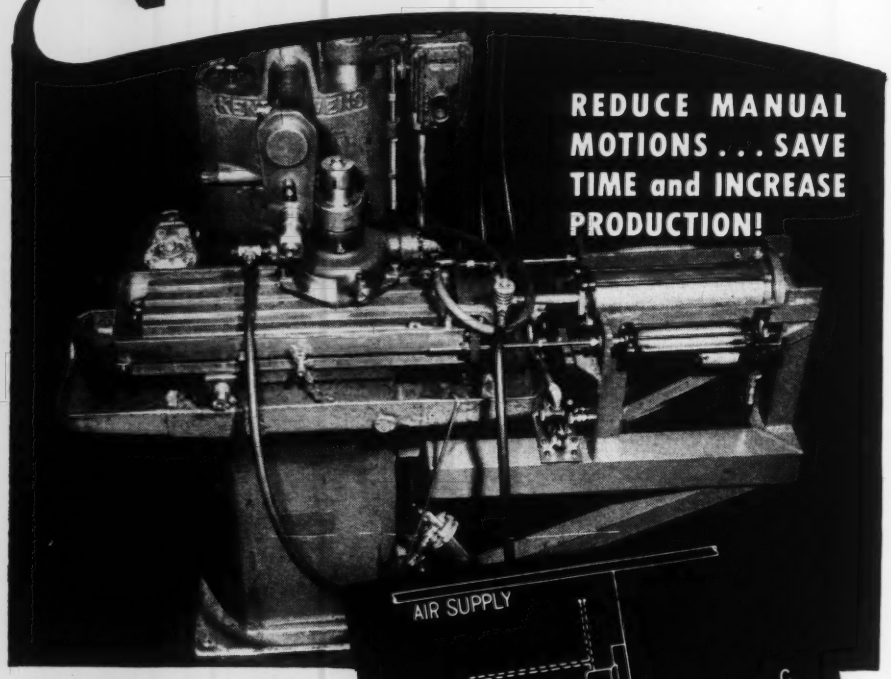
At the PROFIT End of the Machine

Power Transmission by

AMERICAN

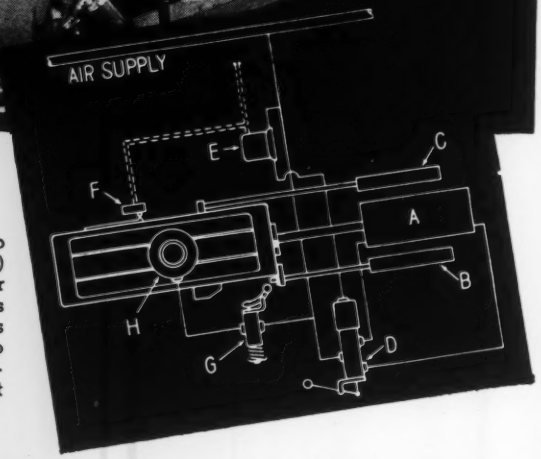
PULLEY COMPANY

LET **Valvair** *Substitute Air for Muscle!*

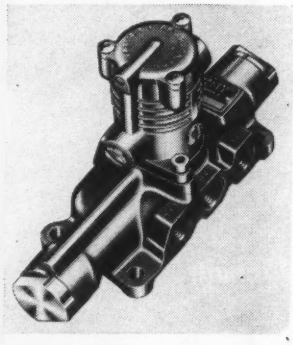


Slot-milling on Horizontal Milling Machine

Move lever of Valvair (D) to start cycle. Air cylinder (A) advances table to work. After cut, limit switch (F) actuates pilot valve (E), which returns valve (D) and cylinder (A) to starting position. Cam-operated Valvair (G) indexes part for next cut.



All air control valves and the installation are by Valvair. Valvair's basic body design fits nine control assemblies. Internal parts are also interchangeable. Valvair *Diversatility* puts real flexibility into your plant operation. Let Valvair engineers or your local Valvair representative assist with your pneumatic circuit problems.



★ ★ ★

The Valvair Speed King line is complete — 3-way, 4-way, 4-way-5-port (2-pressure), foot-mounted or sub-base manifold mounted; pipe sizes — ¼", ⅜", ½", ¾", 1". A precedent-breaker in size, weight, speed and endurance.

"Cut it out!"

☐ ☐ MORE INFORMATION ON VALVAIR LINE
☐ BULLETIN "D-2" ON NEW SOLENOID PILOT VALVE

Name, title_____
Company_____
Address_____

VALVAIR CORPORATION • 953 Beardsley Avenue, Akron 11, Ohio

Valvair DIVERSATILITY

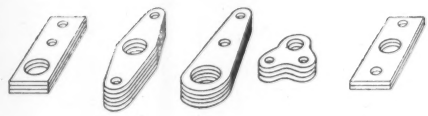
New Parts

ture-free air conditions and for temperatures up to 200 F. Both feature minimum restriction to air flow. Special sound-absorbing material can be used for operation above standard temperature. CA series is available in pipe sizes up to 6 in., LCA series for larger sizes. Made by **Burgess-Manning Co.**, Libertyville, Ill.

For more data circle MD-100, Page 211

Laminated Shims

Line of laminated anchor nut or reinforcing shims is available in five standard shapes and fabricated from aluminum, steel or stainless steel. Sizes range from No. 6 to



⅜-in. bolt in increments of 1/64-in. thickness. Laminations are highly resistant to peeling. Made by **Thomas Associates,** 4607 Alger St., Los Angeles 39, Calif.

For more data circle MD-101, Page 211

Roller Gear Drives

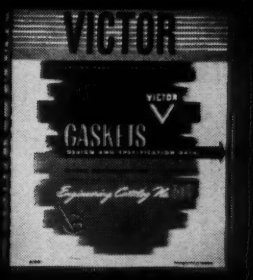
Completely housed Ferguson roller gear drives are designed for intermittent motion and high-speed precise indexing applications. Wide

Practical Approach to Head Gasket Specs

AN EXCLUSIVE VICTOR SERVICE TO DESIGNERS

	TYPES	STRUCTURES	SECTION
HEAVY-DUTY RANGE	LM	.012 copper top .0094 steel layers .012 steel bottom	
	VIC-2-FOLD	.013-.0145 copper top .045-.050 asbestos layer .015 steel bottom	
	VIC-2-FOLD	.012 copper top .040-.045 asbestos layer .012 steel bottom	
	W.I.	.0094 steel top .060-.065 asbestos .015 steel bottom .054 steel wire	
	W.F.	.0085-.0095 copper top .050-.055 asbestos layer .0085-.0095 copper bottom .012 steel web flange	
	D.O.	.0094 steel top .060-.065 asbestos .012 steel bottom	
	V.R.	.0085-.0095 copper top .070-.075 asbestos layer .013-.0145 copper bottom .0094 steel VR flange	
	S.O.	.0094 steel top .060-.065 asbestos layer .015 steel bottom	
	C.T.	.040-.045 C.S. corbestos .0083 steel shim .040-.045 C.S. corbestos .0094 steel flanges	
PASSENGER CAR RANGE	VIC-2-FOLD	.0085-.0095 copper top .035-.040 asbestos layer .0094 steel bottom	
	T.A.	.0077 steel top .015-.020 asbestos layer .0083 steel bottom	
	S.C.	.015 or .020 steel	
	C.F.	.060-.065 CP corbestos .012 steel flange	
	D.O.	.0085-.0095 copper top .060-.065 asbestos layer .012 copper bottom	
	C.F.	.060-.065 CP corbestos .0094 steel flange	
	S.O.	.0094 steel top .060-.065 asbestos layer .0094 steel bottom	
	S.O.	.0085-.0095 copper top .060-.065 asbestos layer .0085-.0095 copper bottom	
	CORBESTOS	.060-.065 CP corbestos	

COMPARATIVE RATINGS of 18 most commonly used head gasket structures, based on blow-by and burn-out factors.



GET THIS RATING CHART and other valuable sealing data in the new VICTOR ENGINEERING CATALOG No. 505—supplied to design engineers on request.

THE MARK OF QUALITY
VICTOR
GASKETS AND OIL SEALS
SEALING PRODUCTS THROUGH RESEARCH
LEADERSHIP THRU PIONEERING

This chart with supplementary data gets you quickly to the special requirements and cost factors that influence final head gasket specifications. It eliminates time-taking search and study of gasket design that may be found unsuited to your application. It helps prevent over-sealing as well as under-sealing.

Here's an example of the complete service available to automotive engineers only from Victor. This dependable data is one of many good reasons for keeping your new Victor Engineering Catalog No. 505 close at hand. Copy sent on request. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill.

VICTOR GASKETS • PACKINGS • OIL SEALS

SEALING PRODUCTS *EXCLUSIVELY*

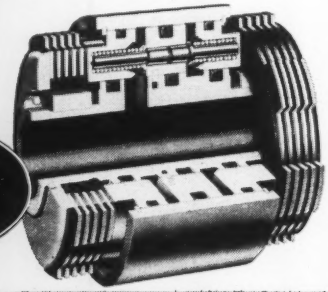
Giddings & Lewis Standardizes on . . .

New Twin Disc Oil-Actuated Multiple Plate Clutches!

For *more constant* torque . . . *longer* wear life . . . *higher* capacity for size . . . *elimination* of adjustment . . . and remote control at *less cost* . . . Giddings & Lewis have standardized on the new Twin Disc Oil-Actuated Multiple Plate Clutch for their "50 Series" Horizontal Boring, Drilling and Milling Machine. Giddings & Lewis—who worked closely with Twin Disc on pilot installations—will utilize two Model MOD (duplex) and four Model MOS (single) Clutches on their "50 Series."

Write to Twin Disc for information on how this all-new Oil-Actuated Multiple Plate Clutch might be applied to *your* machines.

Below, new Model MOD (duplex) Oil-Actuated Multiple Plate Clutch provides consistently longer wear life. Floating or pressure plate is ram of cylinder. As stack wears, ram travel increases automatically.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

TWIN DISC

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

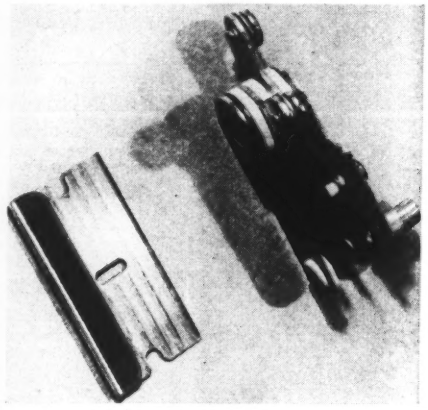
BRANCHES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • SEATTLE • TULSA

range of standard and semi-standard models meets any desired combination of directions of rotation and location of shaft extensions. Mountings can be in any position. Other features include splash lubrication, easily replaced ball bearing followers, antifriction shaft support and tapered output shafts with keyways. Made by **Ferguson Machine and Tool Co.**, P. O. Box 191, St. Louis 21, Mo.

For more data circle MD-102, Page 211

Thermostat

Uni-Therm manual-reset thermostat is designed primarily as a high limit cutout that instantaneously snaps off at a predetermined temperature. It will not remake



until the reset button is pushed. Quick thermal response makes it suitable for air conditioners, room heaters, coffee makers and other devices calling for high temperature protection. Alternating and direct current ratings in any calibration up to 550 F are available. Made by **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

For more data circle MD-103, Page 211

Permanent Magnet Alloy

Alnico 5Cb alloy offers an energy product of 5.70 x 10^6 B Hd. Similar in physical characteristics to Alnico 5, but with higher external energy and residual reduction, it is designed for electrical

Case History M-122

Here's what we mean by *SUPERIOR* ENGINEERED FOUNDRY PRODUCTS...

PROBLEM:

1. This crawler tractor steering lever, a weldment of steel plate and bar stock, was expensive to make.
2. It lacked eye-appeal and detracted from the efficient appearance of the tractor.
3. Dimensional stability was difficult to maintain.
4. Assembling and machining time was excessive.

SOLUTION:

A *SUPERIOR* ENGINEERED FOUNDRY DESIGN MALLEABLE IRON CASTING. It would cost less to produce, it would look better, dimensional stability would be maintained. It would have the rigidity and strength inherent in properly designed malleable iron castings.

RESULT:

1. Production costs reduced.
2. Greatly improved appearance.
3. Dimensional stability easy to maintain.
4. Assembly time eliminated, machining time reduced to a minimum.

TOTAL COST OF PART REDUCED 19.5%.

YOU, TOO, CAN BENEFIT BY CONSULTING *SUPERIOR'S* PRODUCT DEVELOPMENT SERVICE.

It will help solve your design problems, help save you time and money. Through *Superior* Engineered Foundry Design you get maximum advantages of quality, cost, performance, machining, assembly, weight, appearance . . . any or all in a single product.

Make your parts *Superior* Engineered Foundry Products . . . malleable iron castings to 300 pounds, steel castings to 30,000 pounds. It will pay you to get in touch with *Superior*.

Have you entered the first annual Product Development Contest sponsored by the Steel Founders Society of America? We'll be happy to send you the details. Just drop us a line.

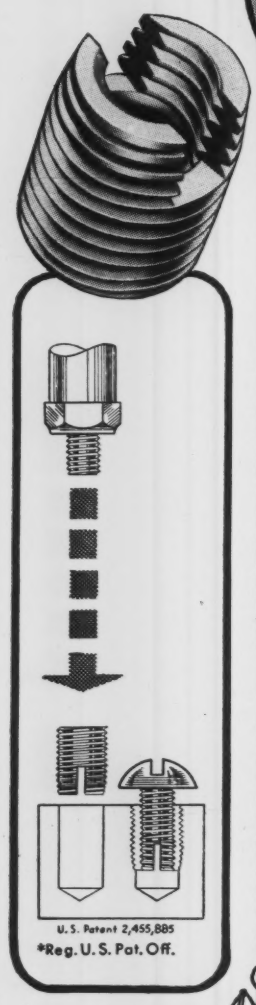
SALES OFFICES: CHICAGO 4, Railroad & Industrial Products Co., 332 S. Michigan Ave.
DETROIT 35, Ray T. Morris, 18050 James Couzens Highway
BUFFALO 21, Gibney-Coffman Corp., 2107 Kensington Ave.

ENGINEERED FOUNDRY PRODUCTS

SUPERIOR STEEL AND MALLEABLE CASTINGS CO.

BENTON HARBOR, MICHIGAN, U. S. A.

Making Good Castings For Quality-Conscious People Since 1916



When a threaded fastener is screwed into soft metal, something must be done to strengthen the female threads. Otherwise these threads quickly wear and strip and the fastener is either lost or made useless.

Of all the bushings now offered for strengthening the parent material at the tapped thread location, the Tap-Lok Insert* is outstanding for its effectiveness and for its savings in first cost, as well as in over-all cost. Because it is self-tapping, it eliminates the time-consuming separate tapping operation. The friction lock imparted to the insert by the self-tapping operation enables it to withstand vibration without loosening and assures maximum torque and pull resistance. It is not subject to the failures of cast and molded inserts.

Tap-Lok Inserts are used primarily as original equipment on regular production line assembly. They are also used extensively in production salvage and in maintenance work.

GROOV-PIN
TRADE MARK REG. U.S. PAT. OFF.

Send for descriptive folder

Also manufacturers of Groov-Pins for positive locking press fit.

GROOV-PIN CORPORATION

1129 Hendricks Causeway Ridgefield, New Jersey

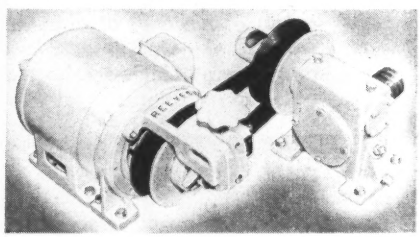
New Parts

electronic and industrial applications, making possible weight and space reductions in product design. Made by **Thomas & Skinner Steel Products Co. Inc.**, 1177 E. 23rd St., Indianapolis, Ind.

For more data circle MD-104, Page 211

Variable-Speed Assembly

A new variable speed disk assembly makes possible use of Flexi-Speed variable speed unit for driving at recommended speeds to gear reducers of either worm or helical type. It can be mounted in

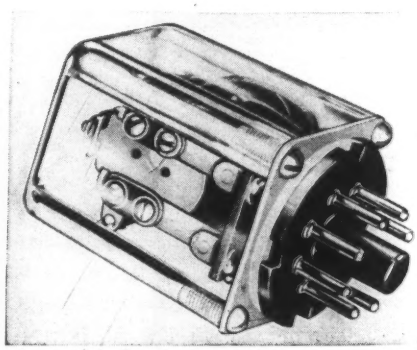


almost any position around the driven equipment, driving in any direction and delivering any desired speed within a ratio of 6:1. Six different belt lengths offer a wide choice of center distances. Unit is available in ½, ¾ and 1-hp capacities. Made by **Reeves Pulley Co.**, Columbus, Ind.

For more data circle MD-105, Page 211

Plug-In Relay

KCP plate circuit, current actuated plug-in relay is enclosed in a clear polystyrene dust cover. It is intended for use in equipment employing photo-electric cell control or similar electronically operated

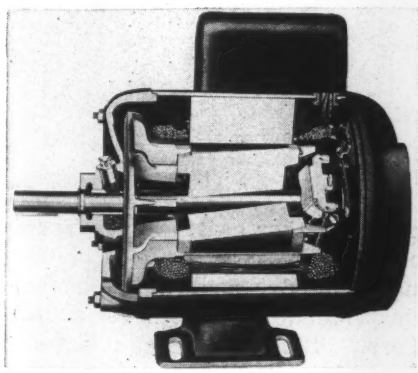


circuitry. Contact rating is 2-amp, 115-v ac noninductive load. Operating coil power is 125 milliwatts per movable pole with a contact pressure of approximately 10 grams. Eight models are available, each with 2500, 5000 and 10,000 ohm coil ratings, and with single-pole, single-throw; single-pole, double-throw; double-pole, single throw; and double-pole, double-throw normally open or normally closed contact combinations. Nominal pull-in values are 3.6, 5.0, 7.2 or 10.0 ma. Made by **Potter & Brumfield,** Princeton, Ind.

For more data circle MD-106, Page 211

Fractional-HP Motors

Form F fractional horsepower motors of rerated design produce more power for a given frame size than previous models. They are available in split phase, single phase and capacitor start induction types and in squirrel-cage



polyphase styles for light and heavy starting loads and general purpose use. Horsepower ranges are from 1/6 to 1 and frame sizes from 62 to 68. Made by **Century Electric Co.,** 1806 Pine St., St. Louis 3, Mo.

For more data circle MD-107, Page 211

Synthetic Rubber Compound

Such properties as resistance to 300 to 325 F temperatures, good oil resistance and low compression set at elevated temperatures are formulated into compound 1225, a Buna N synthetic rubber. Product

When YOUR product designs call for VACUUM OR AIR PRESSURE

They give your Customers service like this:

- "Almost continuous operation, 24 hours a day for 21 years."
- "Operating for 12 years without requiring any maintenance attention whatsoever except for lubrication."
- "No noise to be heard above the sound of the motor."
- "Using Leiman pumps on 350 machines. In no instance has a pump given a moment's trouble."

Whether you're designing vacuum packing and filling machines . . . paper feeding agitators . . . vacuum chucks . . . liquid transfer equipment . . . or any other device requiring continuous, non-pulsating flow of air for vacuum or pressure, it will pay you to investigate the construction and service features of Leiman rotary positive pumps.

4-WING TYPE (illustrated above). Wings hinged to piston—centrifugal force maintains close, continuous contact to cylinder wall. Wings take up their own wear. Vacuums to 20"; pressures to 15 lbs.; displacement to 162 cfm.

2-WING TYPE. Patented wing adjuster pushes wings out into contact with cylinder wall. Combined action of wing adjuster and centrifugal force prevents sticking or binding. Vacuums to 29.9"; pressures to 25 lbs.; displacement to 40.8 cfm.

LEIMAN BROS., INC. 169 CHRISTIE ST. NEWARK 5, N. J.

MAIL COUPON FOR TECHNICAL DATA AND BLUEPRINTS OF 60 TYPICAL APPLICATIONS

SEE OUR CATALOG IN SWEETS FILE

LEIMAN BROS., INC.
169 Christie Street, Newark 5, N. J.

Gentlemen:

Please send me your Catalog No. 752 on Leiman pumps, and Bulletin 90150 showing 60 representative applications.

My Application.....
Name.....
Title.....
Company.....
Street .....
City.....Zone.....State.....

The TERRALOAD'R, built by American Tractor Corp'n., Churubusco, Ind., features HYDRECO Oil Power which contributes to its great versatility, ease and speed of operation as Loader, Dozer and Excavator.

The famous Four-Bolt design HYDRECO Pump which locates the assembly bolts in the area of greatest internal pressure. 3 to 130 gpm for working pressures to 1500 psi at speeds to 2000 rpm.

Yes, the TERRALOAD'R is

Oil Powered by a

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HYDRAULIC PUMP

No glass-house weakling is the TERRALOAD'R. Out where the going is rough ...moving stones, gravel, sand or dirt... day after day...rain or shine...There you find the TERRALOAD'R! And the source of its hydraulic power is a sturdy, dependable HYDRECO Four-Bolt Pump delivering 7 gpm at 1000 psi.

HYDRECO Hydraulic components are original equipment on more and more hard working vehicles in the construction, agricultural and earth moving fields, because they perform up to the expectations of design engineer and operator alike.

Write for complete information on HYDRECO Pumps, Motors, Valves, and Cylinders for your hydraulic circuits.

HYDRECO Gear Type Motors featuring the easily serviced Four-Bolt design ... fully reversible ... delivering up to 52 hp.

HYDRECO Hollow Plunger Valves with capacities of 5 to 80 gpm ... 1 to 5 single or double acting plungers ... covering virtually any application.

HYDRECO Single Acting, Double Acting, and Telescopic Cylinders as well as those of special design.

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1106 EAST 222nd STREET • CLEVELAND 17 • OHIO

is flexible at −40 F and has tensile strength of 2500 psi, elongation of 350 per cent and durometer reading of 70 points. These properties make it practical for transmission and power steering applications as well as fabricating into any type industrial rubber part. Developed by **Goshen Rubber Co. Inc.**, Goshen, Ind.

For more data circle MD-108, Page 211

Foot Switch

Only one of the two circuits incorporated in the Executive foot switch can be operated at one time. Low selective unit is comfortably operated from any heel

height. Either switch, or both, can be wired as normally-open or normally-closed, single-pole, double-throw. Made by **Linemaster Switch Corp.**, 428 Woodstock Terrace, Woodstock, Conn.

For more data circle MD-109, Page 211

Shaded-Pole Motor

Compact continuous duty model MS-3600 shaded-pole motor is built to withstand high temperatures and rough service. It is a four-pole alternating current motor, available in either two or four-coil design. Self-aligning oil-impregnating sleeve bearings and dynamically balanced rotors are incorporated. Operation is on 115-v, 60-cycle ac. It can be equipped with external fan and shaft of any specified diameter and length. Two-speed operation is optional. Made

LARGE SIZES AND INTRICATE SHAPES CAN NOW BE FORGED

The press forgings produced by Cameron approach for the first time the broad field of intricate shapes and patterns that have been limited heretofore to steel castings. Thus, the many manufacturing advantages of steel forgings are made more widely available. These advantages include controllable grainflow characteristics and a uniformly high quality, free from internal defects such as porosity and inclusions.

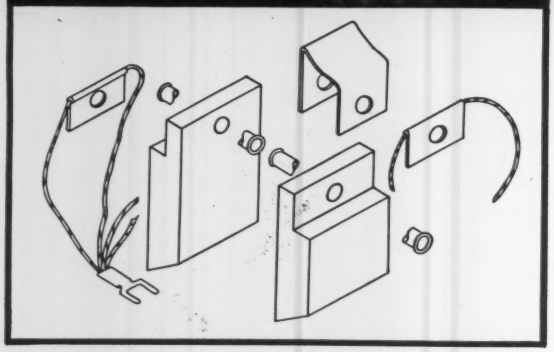
The Cameron forging process opens the door to a great many design features which will aid in producing equipment of greater utility and at a lower cost in manpower and material.

FORGE AND ORDNANCE DIVISION

Cameron

IRON WORKS, INC.
HOUSTON, TEXAS

This SUPERIOR SPLIT BRUSH keeps in touch all the time!



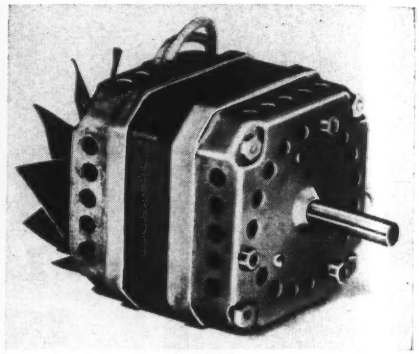
—no other brush just like it!

THE WORD IS GETTING AROUND... More and more, the impression is growing, and rightly, that Superior likes to grapple with difficult brush problems — *and solve them!* The ECH brush assembly shown above does a better job wherever a split brush is required. Superior's patented tension-clamp keeps at least one half of the brush ALWAYS in contact with the commutator. *Results:* optimum commutation, negligible chatter, minimum "brush bounce", and long wear... It would be a real pleasure to study your difficulty — *and without obligation.*

SUPERIOR CARBON PRODUCTS, INC.
9115 GEORGE AVENUE, CLEVELAND 5, OHIO

SCP SUPERIOR CARBON BRUSHES "Since 1919"

New Parts

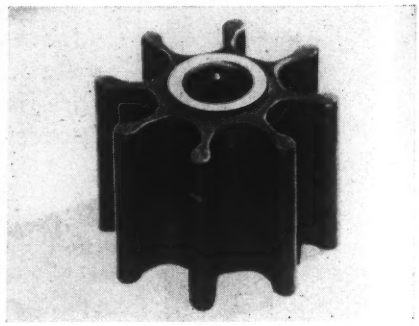


by **Electro Engineering Products Co. Inc.**, 609 W. Lake St., Chicago 6, Ill.

For more data circle MD-110, Page 211

Rubber Pump Impeller

Rubber pump impeller with bonded metal core or bushing permits passage of foreign body through water or other fluid pump without jamming or breaking. Impeller is also available for use in



pumps either lined with rubber or fabricated completely from rubber for more severe service. Made by **Acushnet Process Co.**, Acushnet and Slocum Sts., New Bedford, Mass.

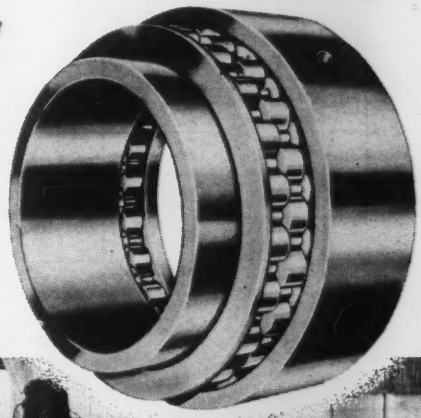
For more data circle MD-111, Page 211

Mercury Contactor

Model HD-7 is a three-tube relay for control applications using heavy amperage. Each tube controls up to 60 amp at 115 v ac and 35 amp at 230 v ac. Direct current control capability per tube is 12 amp at 115 v. Each tube can control 2 hp on ac and ½-hp on

Exceptional load capacity and heavy-duty operation of

ORANGE "STAGGERED" ROLLER BEARINGS

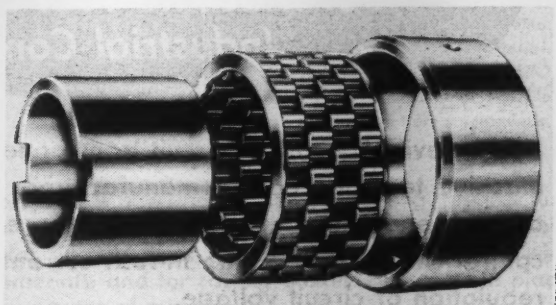


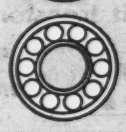
--proved by 10 years' Rugged Service in the Plate Mill at KAISER STEEL CORPORATION, FONTANA WORKS

Orange Staggered Roller Bearings are installed in the approach table in the two-high roughing stand at the Fontana Works, who report satisfactory experience with Orange bearings since the plant was originally constructed in 1943.

The unique staggered design of Orange Staggered Roller Bearings distributes the load over many short rollers, instead of a few full length rollers. This eliminates skewing tendencies of long rollers—provides closer centers for maximum supporting area—assures smooth, precision running due to uniform distribution of load—and results in longer bearing life and extra margin of safety for your installations.

Orange Staggered Roller Bearings are available in a full range of standard sizes, fully interchangeable with other bearings in complete unit or component parts. Engineering service and stocks in all industrial centers. Submit your problems to our engineering department.

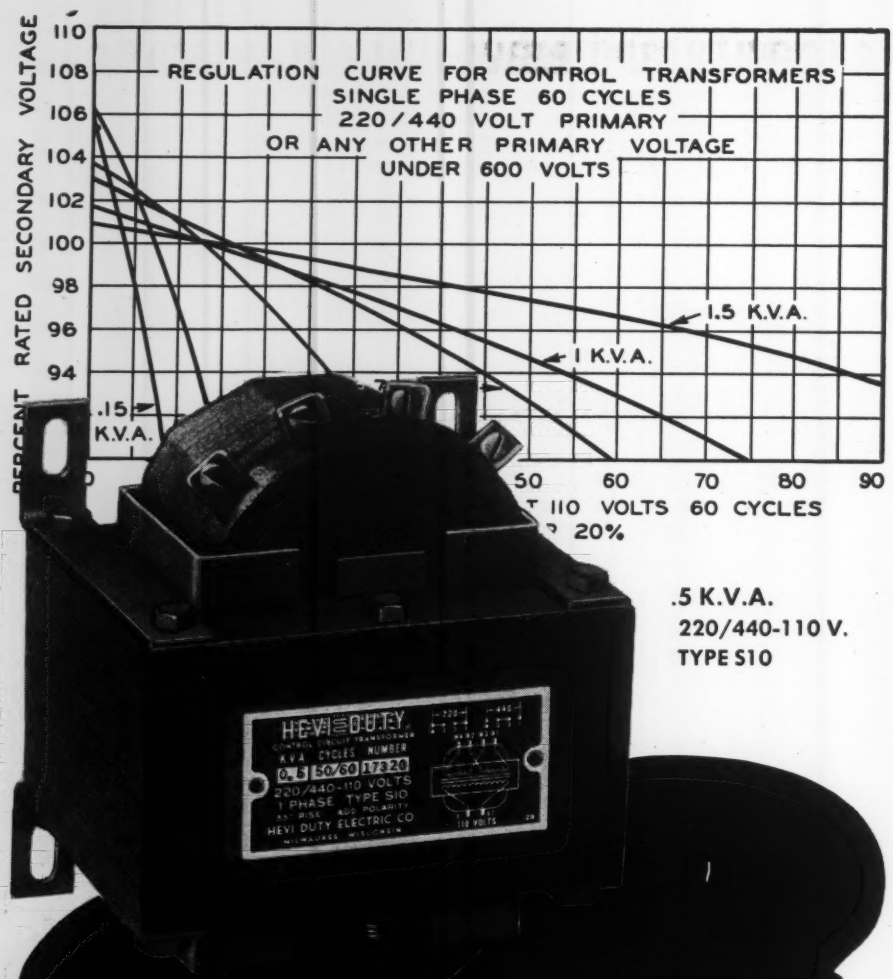




Shown are end views of an Orange "Staggered" Roller Bearing (upper) and a conventional roller bearing. Note how staggered roller design provides a multiplicity of contact points within the loaded zone.

Write for Engineering Data Book showing sizes, capacities, installation data, etc.

ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.



.5 K.V.A.
220/440-110 V.
TYPE S10

HEVI DUTY CONTROL CIRCUIT TRANSFORMERS

For Machine Tool and Other Industrial Controls

Hevi Duty control circuit transformers are specified by many machine tool and control manufacturers because of their superior and dependable performance. They are designed specifically for control circuits where high in-rush currents occur to provide better regulation of circuit voltage.

Write for Bulletin T-5111 for more complete information. This bulletin shows regulation curves, impedance characteristics, and presents other engineering data.

Hevi Duty control circuit transformers are designed to meet or exceed NEMA, ASA and JIC standards.

HEVI-DUTY®

HEVI DUTY ELECTRIC COMPANY

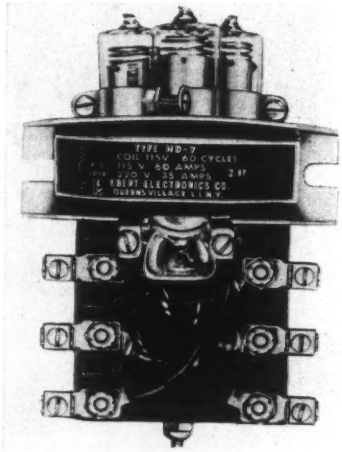
MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

New Parts

dc. Coils are available for various control voltages. Made both normally-open and normally-closed, the relay is rated for normally-open operation at 5 hp at 230 v ac, three phase; at 10 hp at 440 v, three phase. Mercury-to-mercury contacts are provided. The 6 x 4 1/16 x 3-in. unit is silent, chatter-free, hermetically sealed and explosionproof. Made by **Ebert Electronics Co.**, 212-26 Jamaica Ave., Queens Village 28, L. I., N. Y.



For more data circle MD-112, Page 211

Stainless Steel Trap

Stainless steel float trap is designed for draining corrosive liquids from air, gas and steam confined in piping systems and equipment. It operates continuously without permitting air or gas to

COLD CASTING WITH

Thiokol®

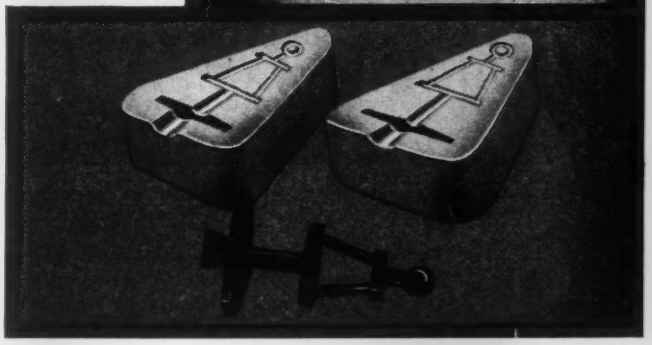
LIQUID POLYMER LP-2

A pourable liquid that converts to a rubber at room temperature

WITHOUT SHRINKAGE

Unlike other rubbers and latices, "Thiokol" LIQUID POLYMER LP-2 is a solventless liquid that is poured and cured cold and does not undergo dimensional change during handling. It cures to a rubber with the following properties:

- **Dimensional stability for an indefinite period**
- **Inertness to water, most oils and solvents, mild acids and alkalis**
- **Toughness and resilience**
- **Stability and flexibility over a broad temperature range**
- **Inertness to ozone, sunlight and aging**



The cold casting compound shown here is made by the Perma-Flex® Mold Co., Columbus 9, Ohio. Thiokol Chemical Corporation supplies LP-2 only as a raw material. Because of its desirable properties, "Thiokol" LP-2 was selected as the elastomer for their line of flexible molding pattern compounds.

The application shown here illustrates the ease of casting "Thiokol" LIQUID POLYMER LP-2 at room temperature. Intricate cavities are permanently filled with a flexible rubber that conforms exactly to the shape of the cavity or mold walls.

The room temperature pourability of "Thiokol" LP-2 coupled with the desirable properties it displays as a cured elastomer have led to its successful application in other fields such as sealing, caulking and filleting.

"Thiokol" LP-2 is now widely used for sealing integral fuel tanks and pressurized cabins in aircraft; for caulking ship decks; for filleting glass and plastics in combination with other materials; and for casting gaskets and seals in place on various types of machinery.

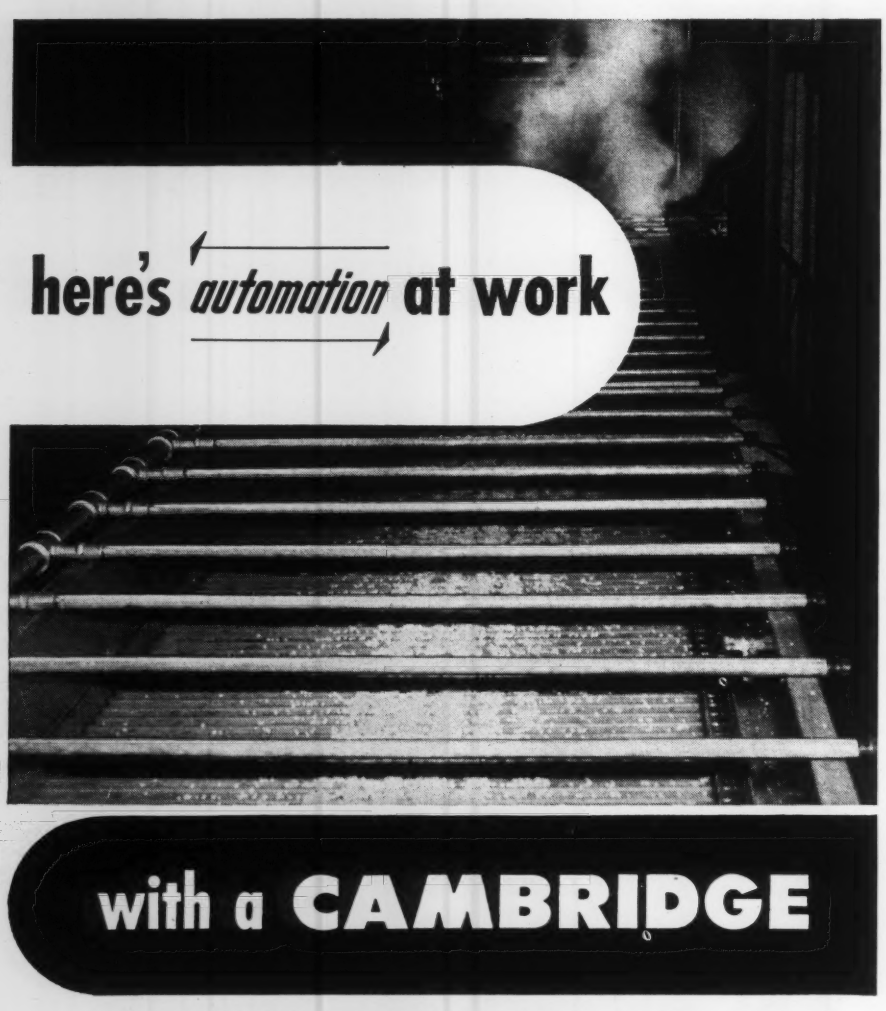
In all of these applications, "Thiokol" LP-2 simplifies production methods and yields desirable product characteristics. "Thiokol" LP-2 may yield similar advantages in your product or process.

Our technical personnel will be glad to discuss the feasibility of employing "Thiokol" LP-2 in any application you have in mind.

Thiokol® Chemical Corporation

784 NORTH CLINTON AVENUE • TRENTON 7, NEW JERSEY

In Canada: Naugatuck Chemicals Division, Dominion Rubber Company, Elmira, Ontario



WOVEN WIRE CONVEYOR BELT!

Cut corn is blanched, cooled and frozen on Cambridge Woven Wire Conveyor Belts. Entire operation is *continuous and automatic,* requires no manual handling until discharge from freezing tunnel.

Regardless of whether your process temperatures range from sub-zero to as high as 2100° F . . . whether you use water rinses, acid pickles or other corrosive processes . . . a Cambridge woven wire belt can help you cut manufacturing costs by contributing to automation . . . continuous, automatic production.

Cambridge belts are all metal and can be woven from any metal or alloy. Thus, they are impervious to damage from heat, cold or corrosive conditions. That's why they can be used to process parts or materials while moving from one location to another.

Because of their open mesh construction they permit free circulation of process atmospheres, free drainage of process solutions. They are available in a wide range of specifications for carrying light or heavy loads, large or small parts.

Special raised edges or cross-mounted cleats to hold your product on the belt during flat or inclined movement are easily supplied.

Get the full story—FREE! Learn how Cambridge Woven Wire Conveyor Belts can help you boost efficiency by continuous, automatic production . . . *automation!* Write today for your copy of this manual of belt applications. It's the most complete text available.

Or, for immediate advice, call in your Cambridge Field Engineer. You can rely on him to make just the right recommendation for you. Look under "Belting-Mechanical" in your classified phone book, or write direct.

The Cambridge Wire Cloth Company

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

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CAMBRIDGE 2,
MARYLAND

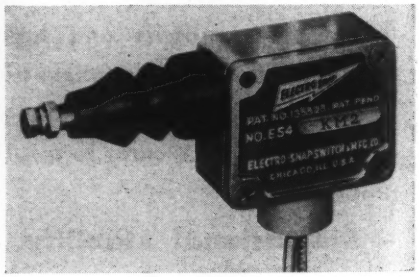
OFFICES IN LEADING INDUSTRIAL AREAS

escape from the system by use of an interlocked valve, seat, lever and ball float system. It is designed for service up to 300 psi and 800 F and is made in sizes from ½ to 2 in. Made by **V. D. Anderson Co.**, 1935 W. 96th St., Cleveland 2, O.

For more data circle MD-113, Page 211

One-Way Impulse Switch

One-way impulse action is featured in the model ES4-KM2 snap-action switch. Typical application is in a switching operation where a pulse to a solenoid or starter is needed. Switch sends the controlling electrical impulse and then drops completely out of the circuit. Choice of five "on" periods, from 1/16 to ⅜-in. is offered. The switch completes the

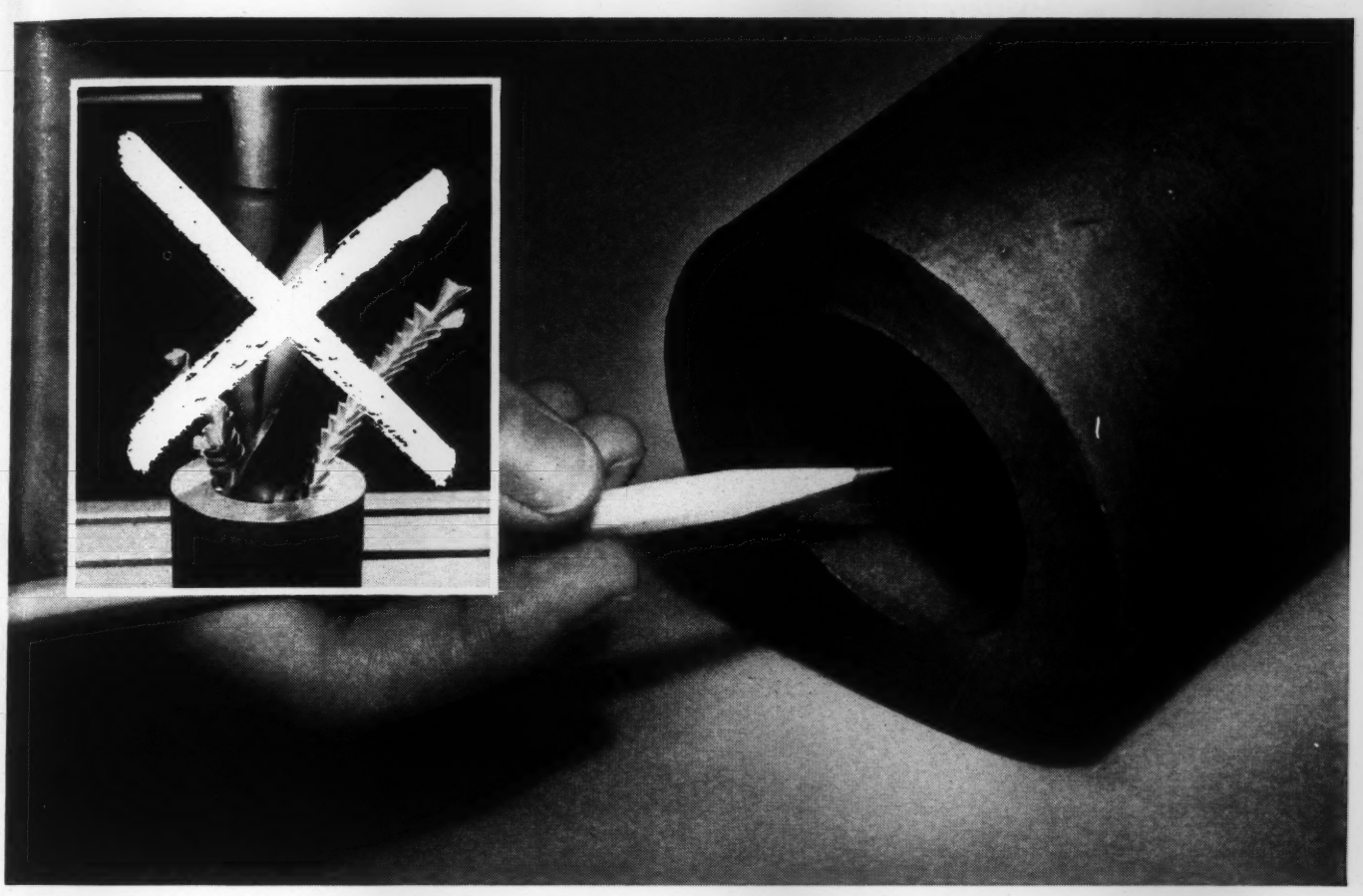


circuit for a predetermined part of the plunger's forward stroke, then releases the impulse as the plunger advances. Actuator plunger is sealed by a Neoprene boot to keep out water, oil and dust. Boot remains flexible between −67 and 160 F. Silicone boots are available for extreme temperatures. Basic switch is single-pole, double-throw type for alternating current circuits. Made by **Electro-Snap Switch & Mfg. Co.**, 4218-30 W. Lake St., Chicago 24, Ill.

For more data circle MD-114, Page 211

Miniature Motor

Miniature permanent magnet motor or generator, smaller than a pack of cigarettes, offers horsepower ratings from 0.004 to 0.0165 and speeds from 2000 to 20,000 rpm, with total weights from 3.5



Eliminate drilling! Finish boring's the first step with TIMKEN® seamless steel tubing!

DRILLING'S a thing of the past when you use Timken® seamless steel tubing. The hole's already there! You save time and money by starting with finish boring.

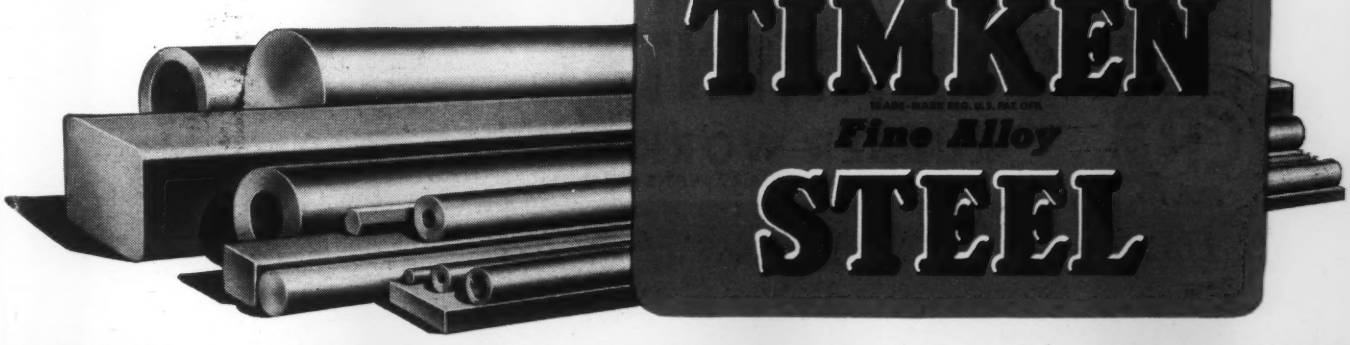
Screw machine stations are available for other jobs. The result: You add machine capacity without adding machines.

Timken seamless steel tubing saves you additional money because you don't waste steel. All you pay for is the steel you use. We give you the holes.

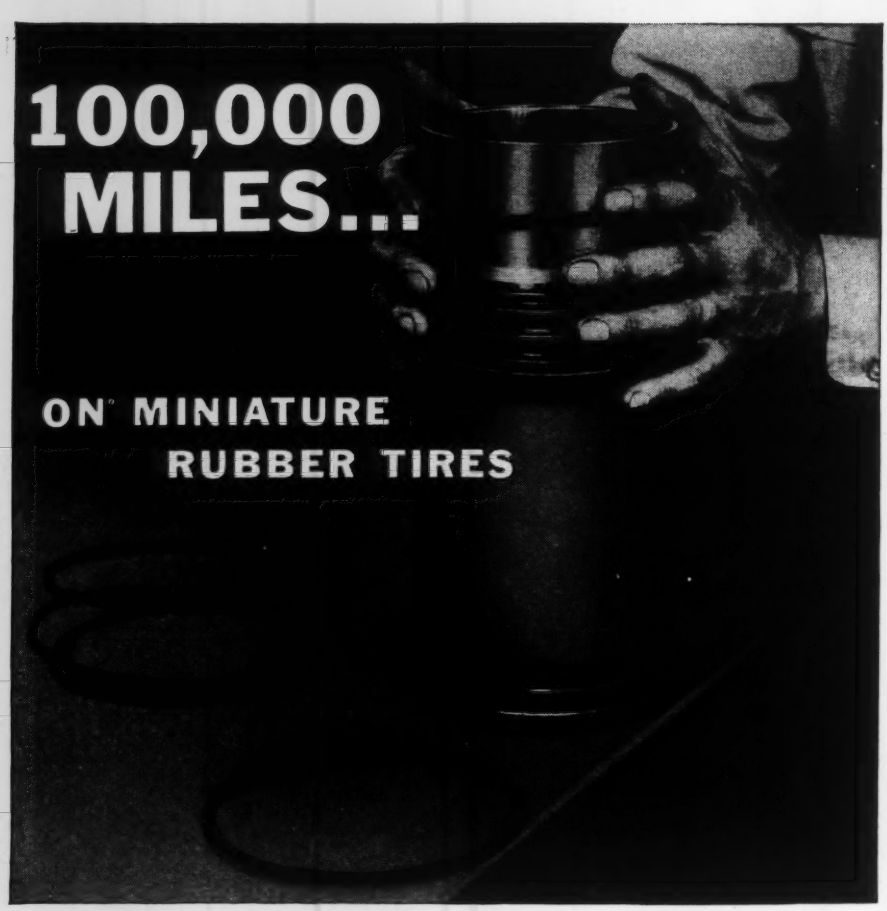
To make sure you get the most steel per dollar, our engineers will be glad to study your problem and recommend the most economical tube size for your hollow parts jobs.

Timken seamless steel tubing gives you high internal quality because the piercing process by which it's made is basically a forging process. It has a uniform spiral grain flow for greater strength, and a refined grain structure which brings out the best in the quality of the metal. And our rigid quality control makes sure that the quality is uniform from tube to tube and heat to heat. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING



Photograph courtesy of
Cummins Engine Company, Inc., Columbus, Indiana

Tire-shaped rubber packing rings for cylinder liners in Cummins diesel engines are small but important. They provide a seal between oil and water—a seal that must be perfect whether the engine is cold or operating at high temperatures. Moreover, these rubber rings must stand up for at least the equivalent of 100,000 miles of operation.

These severe operating requirements presented a rubber problem with exacting specifications: resistance to sustained heat—controlled swell in oil—exceptional compression quality—precision tolerances.

Continental met all these specifications and produced a rubber ring that gives outstanding service in an outstanding diesel engine.

The successful production of this specialized rubber part is typical of the complete service in rubber offered by Continental.

When *you* need molded or extruded rubber parts, why not enlist the assistance of Continental?

LET US SEND YOU THIS CATALOG

This new engineering catalog lists hundreds of standard grommets, bushings, rings and extruded shapes. It will be a valuable addition to your working file. Send for your copy today or . . .

See our Catalog in Sweet's File for Product Designers

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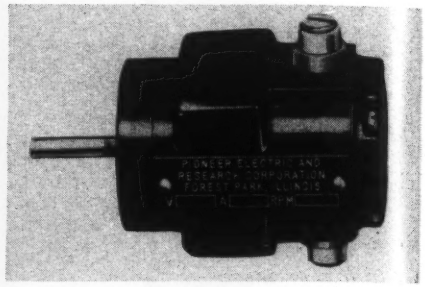
Boston, Mass.	Dayton, Ohio	Los Angeles, Calif.	Rochester, N. Y.
Buffalo, N. Y.	Detroit, Mich.	Memphis, Tenn.	St. Louis, Mo.
Chicago, Ill.	Hartford, Conn.	New York, N. Y.	San Francisco, Calif.
Cincinnati, Ohio	Indianapolis, Ind.	Philadelphia, Pa.	Syracuse, N. Y.

New Parts

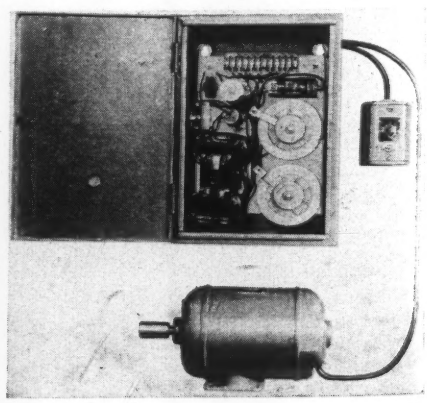


to 9 oz. Its magnetic structure cast into an aluminum housing, the unit has accurately machined line-up indices which fit directly into the field structure bore to assure a uniform air gap between field and armature. Stainless steel shaft, rotor and commutator diameters are precision ground. The motor conforms to JAN specifications for minimum weight, low current consumption and efficiency. Voltage range is 6 to 110 dc. Commutator is 14 bar, and a 35 bar type is also available. Water tight and explosion proof housing, fungicided armature, noise filter, speed governor and gear reducer are optional. Used as a generator operating at 6000 rpm, the unit offers an output range from 1.5 to 8 w. Made by **Pioneer Electric & Research Corp.**, Forest Park, Ill.

For more data circle MD-115, Page 211

Adjustable-Speed Drives

Vari-Amp magnetic amplifier motor drive is a compact unit which provides adjustable motor speeds from an ac power source. It converts ac power from a 115-v, 60-cycle source to power for driving dc motors. Speed is continuously



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SELECTIVE FEEDING DEVICES

Also EXTENDED ENGINEERING SERVICE—
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DPS BOWL-FEEDER

A proved method based on the VIBRATORY PRINCIPLE. Provides fully automatic, oriented, single line feeding to Grinding, Packaging, Inspecting and many other automatic machines and operations. Will scientifically feed light, fragile parts that normally could not withstand tumbling.

DPS BARREL-FEEDER

For years our popular unit, successfully used in thousands of plants to help speed production and reduce costs. They were designed with the idea of simplicity in operation and maximum feeding, handling a wide variety of parts. Designed for constant operation.

DETROIT POWER SCREWDRIVER CO.

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AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet
Subject: INDEX OF ACP CHEMICALS FOR METAL PRESERVATION AND PAINT PROTECTION

METAL	OPERATION	ACP CHEMICAL
ALUMINUM	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
BRASS	Brightening	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK
	Corrosion Prevention	"CUPROTEK"
	Soldering Flux	"FLOSOL"
COPPER, BERYLLIUM, AND COPPER ALLOYS	Brightening	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK"
	Coating Steel with Copper	"CUPRODINE"
	Corrosion Prevention	"CUPROTEK"
	Scale Modification	"RIDOXINE"
	Soldering Flux	"FLOSOL"
	Stripping Copper Coatings	"ACP COPPER STRIPPING SOLUTION"
GALVANIZED IRON, ZINC, AND CADMIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
IRON AND STEEL	Chromate Coating, in Preparation for Painting	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
	Rust Proofing	"PERMADINE" "THERMOIL-GRANODINE"
	Rust Removal—Brush, Dip, or Spray	"DEOXIDINE"
	Soldering Flux	"FLOSOL"
MAGNESIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Pickling	"RODINE (M-200)"
STAINLESS STEEL	Cleaning	"DEOXIDINE"
	Coating with Copper	"CUPRODINE"
	Pickle Polishing	"RODINE"
	Soldering Flux	"FLOSOL"

CHEMICALS ACP PROCESSES

WRITE FOR DESCRIPTIVE FOLDERS ON THE ABOVE CHEMICALS AND FOR INFORMATION ON YOUR OWN METAL PROTECTION PROBLEMS

CHEMICALS ACP PROCESSES

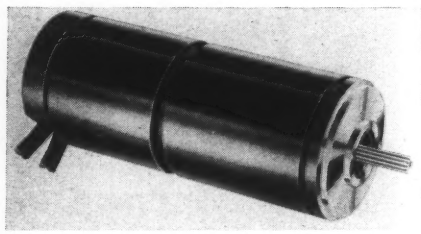
New Parts

adjustable over the complete range by means of a small rheostat located on the control station. The standard unit provides for a speed range of 10:1 and is available with motors ranging from 1/40 through ½-hp. Consisting of a main control panel, a control station and a motor, it is completely self contained and includes, in addition to the variable armature supply, field supply, control circuit and short circuit and overload protection. The device employs a full wave, self saturating, magnetic amplifier unit containing no tubes or moving parts. Made by **Clark Controller Co.**, 1146 E. 152nd St., Cleveland 10, O.

For more data circle MD-116, Page 211

Servo Motor-Generator

Stator assemblies of both motor and generator sections of the type R804 low inertia servomotor-damping generator combination are integrally cast in a thermosetting plastic material. Unit weighs 7.6 oz, has 1.062 in. diameter and is 3 in. long. Stainless steel housings and cast stators provide protection against effects of high temperature, humidity, vibration and shock.



Mounting can be by tapped holes in motor face or by clamps. Motor is a 115-v, 400-cycle, fixed-phase type and draws 3.5 w. Wr^2 for the rotor is 1.3 gram-cm^2; stall torque is 0.63 oz-in. Generator has 115-v 400-cycle excitation and an output of 0.500-v per 1000 rpm minimum. Generator portion can be obtained as a separate unit or integral with certain other Kearfott servo motors for uses requiring higher torque. Made by **Kearfott Co.**, 1150 McBride Ave., Little Falls, N. J.

For more data circle MD-117, Page 211

for a camera clutch or tractor brake

Velvetouch

All-Metal
FRICTION PRODUCTS
give you more dependable starts and stops

You get positive operating uniformity when you specify Velvetouch. Because Velvetouch is all-metal. It's designed to give you field-proven dependability regardless of application.

Unlike ordinary friction material, Velvetouch is made from powdered metals, compressed and fused to a strong steel backing plate. As a result, it runs cooler, lasts longer ... can't deteriorate or burn like asbestos. And by changing the metal mixture, the friction characteristics of Velvetouch can be made to meet specific clutch and brake requirements.

Our engineers will he glad to work with you. Just phone our nearest office, or write—

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* LOS ANGELES—1110 South Hope St., Los Angeles 15, Cal.
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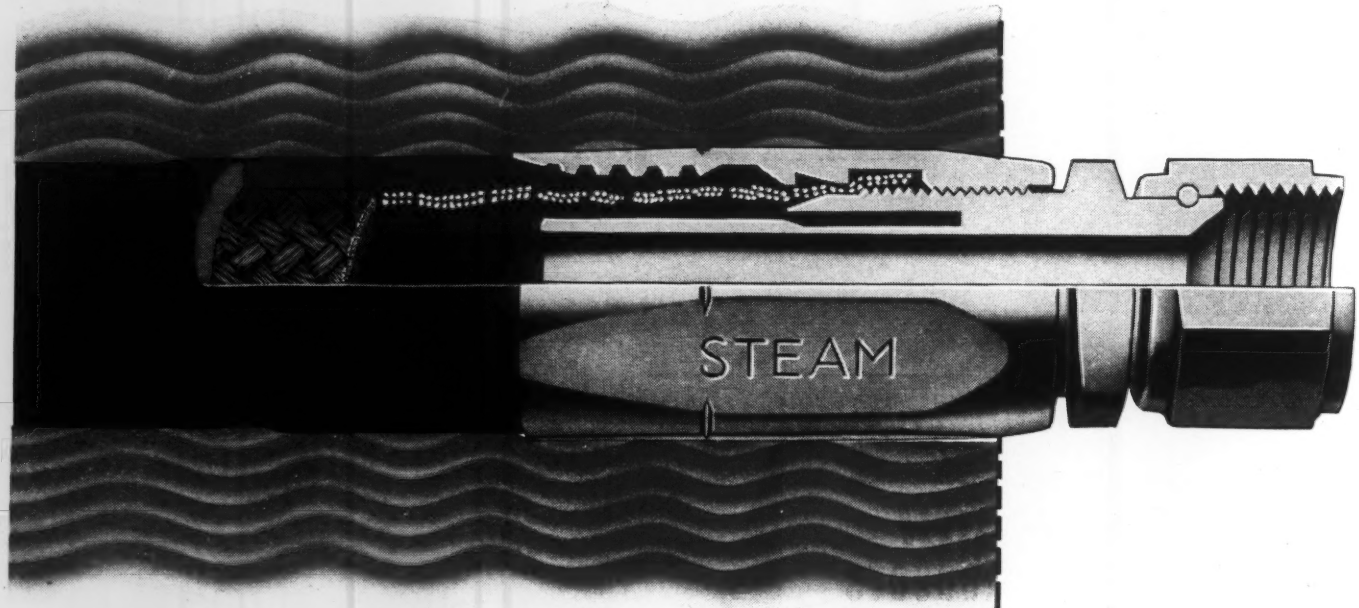
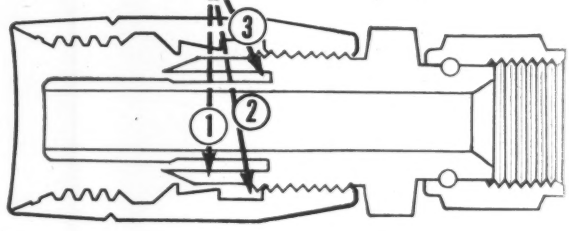
The Steam Hose Line with a FUTURE!

ANOTHER AEROQUIP FIRST!



Now . . . a steam hose line built for extra l-o-n-g life! The secret is in Aeroquip's reusable "*little gem*" fittings that assure positive attachment to the hose and never need re-tightening once assembled. The knife-like spur (1), see diagram, of the "*little gem*" separates the inner tube from the wire braid; clamping action (2) is exerted on reinforcing braid only; and a lip seal (3) is formed by the end of the inner tube in an annular chamber. The "*little gem*" is a streamlined, compact fitting with no bolts or protruding surfaces to hinder handling. In perfect combination with Aeroquip burst-proof steam hose, it offers greater efficiency and maximum safety. *Truly another Aeroquip first in better hose lines!*

Longer Life!



Aeroquip

REG. TRADE MARK

STEAM HOSE MATCHED WITH "*little gem*" FITTINGS

"*little gem*" is an Aeroquip Trade Mark

AEROQUIP CORPORATION, JACKSON, MICHIGAN

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IN CANADA: Prenco Progress and Engineering Corporation Ltd., Toronto

IN ENGLAND: Super Oil Seals & Gaskets, Ltd., Birmingham

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

ENGINEERING DEPARTMENT

EQUIPMENT

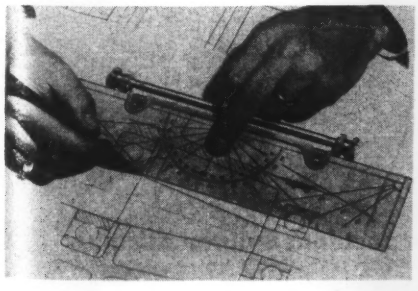
Perspective Graphs

Perspective graphs, for scaling directly from engineering drawings into distortion-free perspective views, are now available in 20 x 33-in. size as well as 30 x 60-in. size. Graphs represent an inversion of the six faces of a cube, each of the six planes being a grid, graduated in true perspective foreshortening, from which dimensions may be plotted and projected as rapidly as isometric projection. Seven basic graphs are included in the set, each designed to view the perspective grids at a different angle. Each graph may be used as a top view or, inverted, as a bottom view. Made by **Tech-Art Graphs,** 315 South 15th St., Philadelphia 2, Pa.

For more data circle MD-118, Page 211

Drafting Instrument

Combining the functions of T-square, triangles, straightedge, scales and protractor, or drafting machines, the Paraline may be used on any flat surface for ordinary



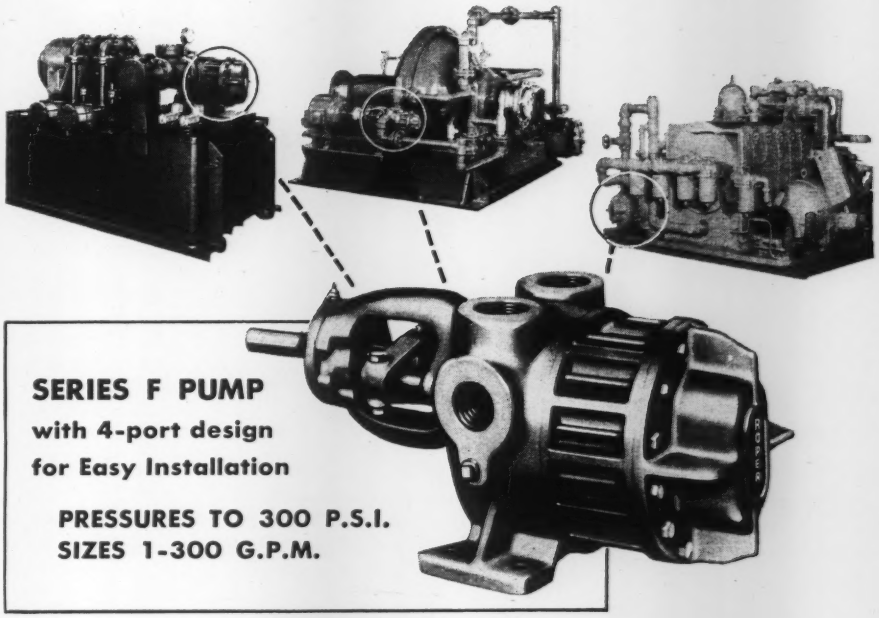
drawings, or to facilitate detail work on very large drawings. It permits rapid projection of angles and tangents and scaling of parallels without raising the device. Cross-hatching is also accom-

(*Continued on Page* 264)

ROPER *Rotary Pumps* **POWER** *That's Dependable*

POSITIVE CONTROL

for Hydraulic Circuits



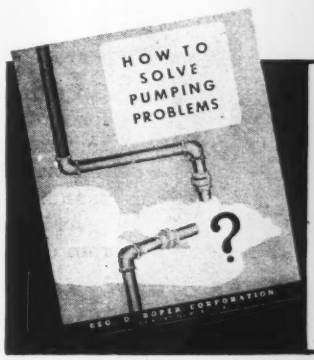
SERIES F PUMP
with 4-port design
for Easy Installation

PRESSURES TO 300 P.S.I.
SIZES 1-300 G.P.M.

Whether you are planning one special machine or hundreds on a production run, consider putting a Roper on the job. Consider 4-port design of the Series F (eight optional piping arrangements — 4 for CW and 4 for CCW rotation) for ease of installation and servicing. Consider, too, the Roper principle of only two moving parts . . . equal size gears operating in axial hydraulic balance . . . standard or stainless steel fitted models, as desired . . . heavy duty flange type bearings. Pumps are supplied with or without relief valve . . . with packed box or mechanical seal. Yes . . . consider Roper for *your* hydraulic applications.

Send for Your Free Copy of New Roper Fact-Packed Booklet!

A valuable 36 page guide that includes tables, charts, and other data relative to the average pumping job. Send for your free copy . . . use coupon below.



Geo. D. Roper Corporation
242 Blackhawk Park Ave.
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Please send copy of your latest catalog and new booklet "How To Solve Pumping Problems".

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CITY.....STATE.....

MICRO Precision Switches

Extreme reliability, small size and low-force actuation

make MICRO switches the choice of Sheffield Corporation engineers in this new giant automatic precision gage

34 MICRO switches control operation of this gage

Main elements of this giant gage consist of a loading station, loading cross-transfer, shell conveyor, electro-pneumatic gaging station, reject cross-transfer and a reject conveyor. The complete gaging cycle is completed automatically in four seconds.

Shells positioned automatically

Operator places shell on loading platform and pushes it forward until it touches Switch **(A)** causing the hydraulic ram to push the shell on to the conveyor.

Switches **(B & D)** reverse the travel of the hydraulic ram after the shell is in position on the conveyor.

As long as the shell is in contact with Switch **(C)** the ram cannot push another shell on to the conveyor.

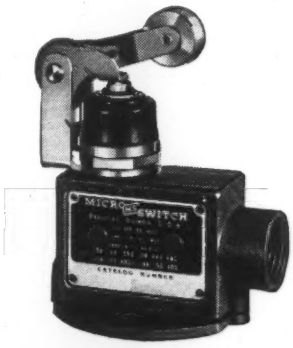
This 10-ton "Chambermatic Gage" automatically checks the uniformity of profile and alignment of 90 millimeter ammunition with increased accuracy and at lower cost. Believed to be the largest gaging device ever built, it is a product of the Sheffield Corporation of Dayton, Ohio.

• • •

MICRO switches . . . 34 of them with six different types of characteristics . . . were selected to control the electro-pneumatic gaging cycle, position the shells in the gaging chamber and stop the machine if any deviation from proper performance should occur.

MICRO engineers cooperated with the engineers of Sheffield to supply switches with exactly the proper characteristics to best perform these important functions. The switches were selected because of:

- **Extreme reliability of performance**
- **Long-life dependability of operation**
- **Accurate repeatability of operating point**
- **Small size and rugged housings**



Design engineers in every phase of industry who are faced with the need for extreme reliability in the switches they select, are finding consultation with MICRO engineers to be the short-cut to success. These competent, fully experienced engineers are located in 16 MICRO branch offices to help you make sure that the switch you choose is the one best suited to your individual requirements.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

FREEPORT, ILLINOIS

H HONEYWELL

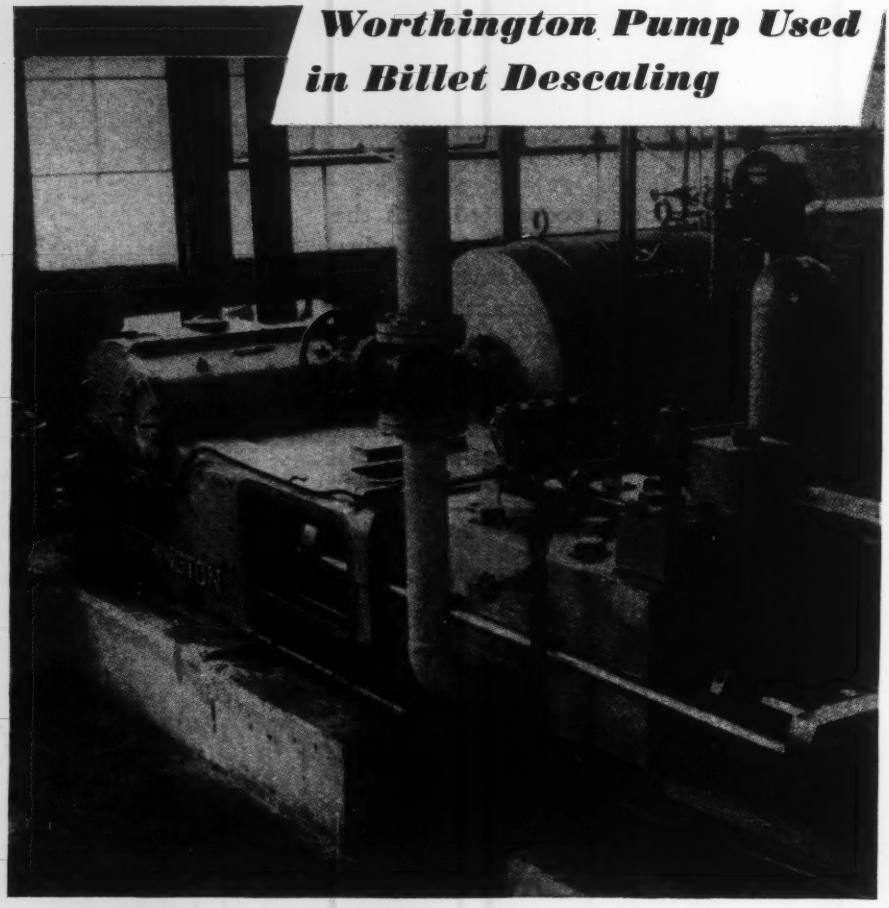
Stop conveyor if shells not removed

For continuous operation, shells must be removed immediately when the unloading station is reached. If they are not removed, these MICRO switches stop the forward travel of the conveyor. This prevents shells being pushed out of the gage if operator is absent.

Provide automatic timing of gaging cycle

The nine MICRO switches shown in this photograph are contacted by the timing cams on this output shaft. They are used to control all the movements and timing of the gaging circuit. A complete gaging cycle takes about four seconds.

Worthington Pump Used in Billet Descaling



is powered by Star-Kimble Motor

This Worthington 2¾" by 12" plunger pump, shown installed at the South Bend Plant of the Oliver Corporation, produces the air pressure needed to force water through the nozzles of a Worthington descaling system. Billets are fed into the descaling cabinet at the rate of 125 an hour. To maintain uninterrupted production flow at this rate of descaling calls for an unfailing supply of water to the nozzles of 110 gpm at 2,500 psi. To power the pump for this service, Worthington selected a Star-Kimble squirrel-cage motor.

IN ADDITION

[redacted]

For information on standard squirrel-cage motors, write for Bulletin B-201.

Standard and special motors of all types, 1 to 125 hp; generators and motor-generator sets, 1 to 100 kw; Marine motors ½ to 125 hp.

Star-Kimble
MOTOR DIVISION
of Miehle Printing Press and Mfg. Co.

201 Bloomfield Avenue Bloomfield, New Jersey

Engineering Equipment

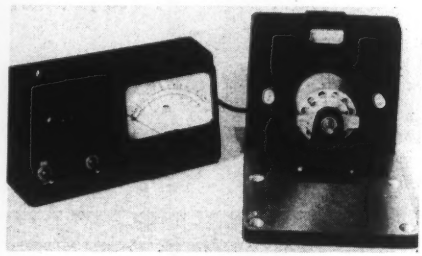
(*Continued from Page* 261)

plished rapidly. Available with engineer's scale, the instrument weighs less than 4 oz and measures 12½ x 3½ in. Made by **Pickett & Eckel Inc.**, 5 S. Wabash Ave., Chicago 3, Ill.

For more data circle MD-119, Page 211

Dynamometer

Eddy current dynamometer has a switch for selecting a high or low scale, the upper position being the high range. The instrument performs in three torque ranges: 0 to 16 in.-oz, accurate to ±1 per cent of full scale reading; 0 to 8 in.-oz, accurate to ±2 per cent of full



scale reading; and 0 to 2 in.-oz, accurate to ±8 per cent of full scale reading. Two speed ranges are provided: 0 to 7200 rpm and 0 to 14,400 rpm, both accurate to ±2 per cent of full scale reading. Made by **Magtrol Inc.**, 533 S. Niagara, Tonawanda, N. Y.

For more data circle MD-120, Page 211

Data Plotter

Electroplotter plots from a variety of input data such as analog or digital computers, punched card machines or manual keyboard. In the latter case a high-speed ten-key keyboard with numerical verifier provides for plotting rates at about 35 points per minute. Pen traversing speed is 18 in. per second; accuracy is ±0.1 per cent. Other characteristics of the plotter include automatic symbol printing, independent zero and scale controls for each axis, selectable incremental advance when required and vacuum table for holding paper. The in-

aircraft component steel parts made from ACCUMET PRECISION INVESTMENT CASTINGS

The pictured castings are currently being used to produce such important aircraft accessories as fuel injectors and regulators, carburetors, landing gear door latch mechanisms, rocket release mechanisms and radar equipment. Cast to close tolerances with smooth surface finish, expensive machining operations are avoided — resulting in saving of valuable time, and reduction in cost. Also *Accumet Precision Investment Castings* permit the use of higher alloyed steels that are difficult or impossible to machine or forge, thus increasing the life or performance of the component parts.

ENGINEERING SERVICE AVAILABLE

Crucible engineers and metallurgists are available to assist you in solving your design or production problems by the application of these Accumet Precision Investment Castings.

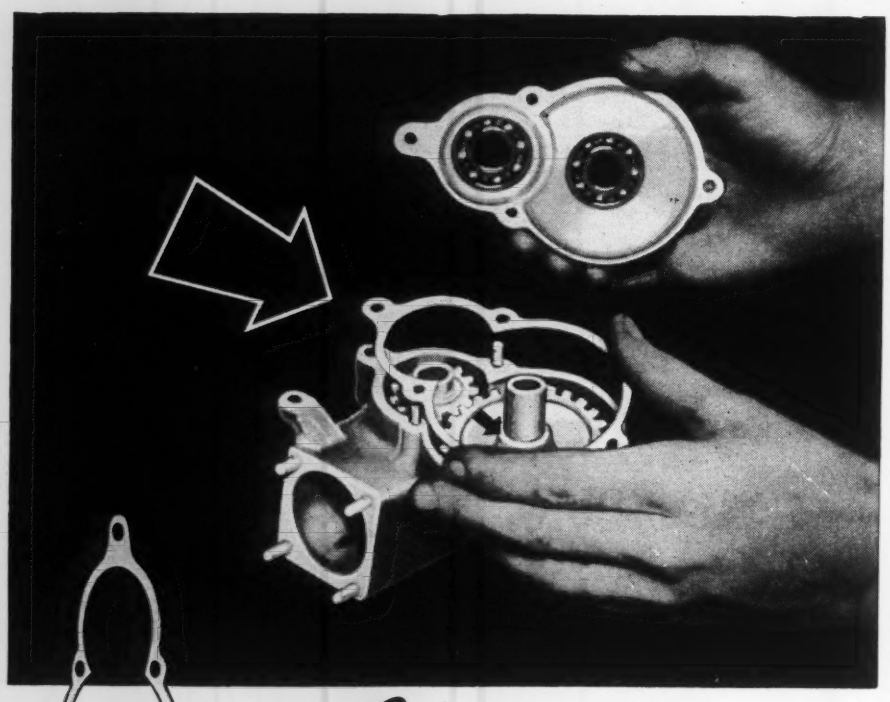
CRUCIBLE first name in special purpose steels

54 *years of* Fine *steelmaking*

ACCUMET PRECISION CASTINGS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS



Shims stamped from LAMINUM® look like solid metal but actually are made up of from 3 to 63 layers of .002 or .003 inch brass or steel.

A "BUILT-IN" ADJUSTMENT THAT ACTUALLY COSTS LESS THAN NO ADJUSTMENT!

. . . there's less machining and you can "take up" after wear.

Think of this shim as an adjustment device. As used here, its cost was only 19¢. It's made of our exclusive LAMINUM®, has 16 layers of .002" brass in one unit.

It gives wide tolerances to the thrust gear housing, saving expensive machining time.

It precisely preloads the bearing. Inner race rests on the collar, marked by arrow. Outer race is "fixed" in the housing. Removal of a .002" shim lamination brings housing and outer race closer to main assembly. This gives the minute preloading adjustment for best angular contact bearing operation.

It "takes up" after wear. Removal of additional laminations makes simple, quick adjustment.

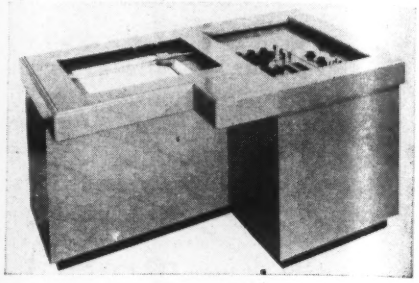
SHIM HEADQUARTERS SINCE 1913

Check Our Stampings Division For Your Stamped Parts Requirements

LAMINATED SHIM COMPANY, INC.

1202 UNION STREET • GLENBROOK, CONNECTICUT

Engineering Equipment

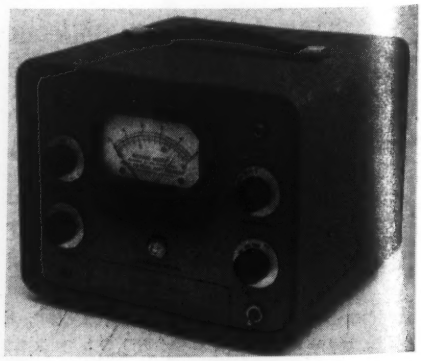


strument uses any type of paper measuring up to 11 x 17 in.; units to accommodate larger sizes are available. Made by **Benson-Lehner Corp.**, 2340 EJ Sawtelle Blvd., West Los Angeles 64, Calif.

For more data circle MD-121, Page 211

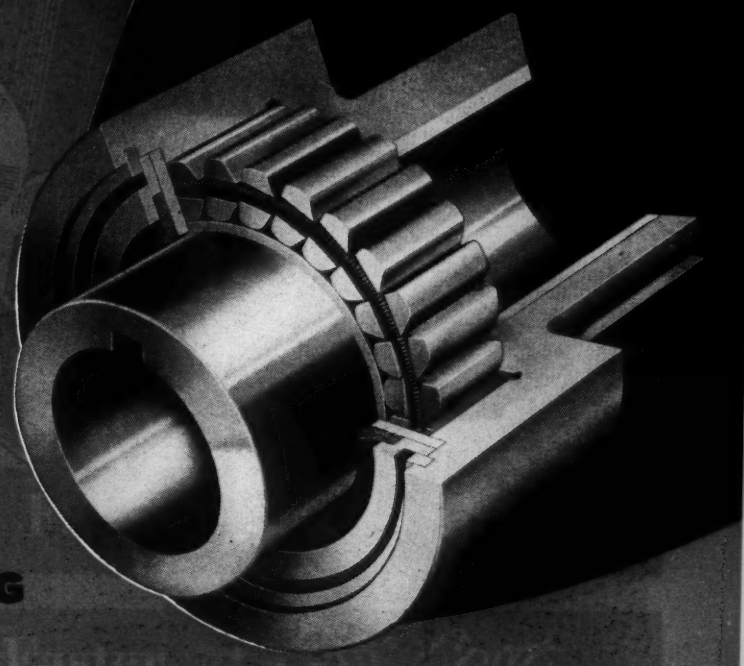
Vibration Meter

Portable type 1-117 vibration meter weighs 25 lb and operates on 115-v, 50, 60 or 400-cycle power. Four self-generating pickups may be mounted on the body under test and their input fed to four connectors on the rear panel. Gain on each input channel can be adjusted individually. Where unwanted low-frequency signals interfere with the desired frequency, three accessory high-pass filters may be used to cut off sharply at 30, 70 or 110 cycles per second. Measured values of both linear and torsional velocity of motion and peak-to-peak displacement are indicated on a direct-reading scale. Full-scale peak-to-peak displacement measurements from 0.0005 to 1.5-in. and linear velocity measurements from 0.5 to 1500 ips average are possible through combinations of the various control settings. For velocity measurement, the flat frequency response is 5 to 5000 cycles



Evolution of the Modern Clutch

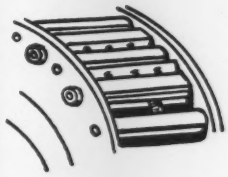
FOR OVER-RUNNING, INDEXING, BACKSTOPPING



First . . . Ratchets

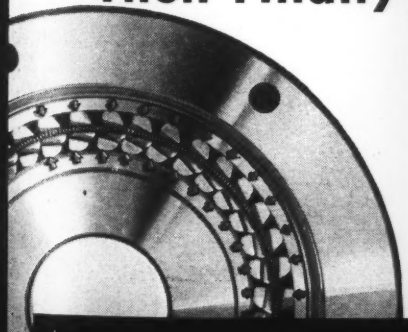
Feeding was inaccurate because of the inherent backlash and speed was limited. It provided only one indexing position and one indexing rate, determined by the number of teeth. And, it was noisy.

Then . . . Rollers



This type had widely spaced rollers. High capacity was not possible without many rollers, resulting in a bulky, space-taking clutch. Clutch life was short: the rollers always gripped at the same inner-race positions.

Then Finally . . . A Full Complement of SPRAGS



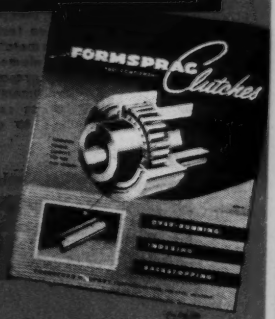
This most modern of clutches—the Formsprag Full Complement—has sprags running on concentric races without ramps. Design of the sprag provides a greater load capacity than any other type of working member. And—there are *more* working members (sprags) than in any other clutch-type. Formsprag's full complement of sprags always means MAXIMUM TORQUE CAPACITY in a small, compact unit.

FORMSPRAG is the FULL COMPLEMENT Clutch!

FORMSPRAG Company

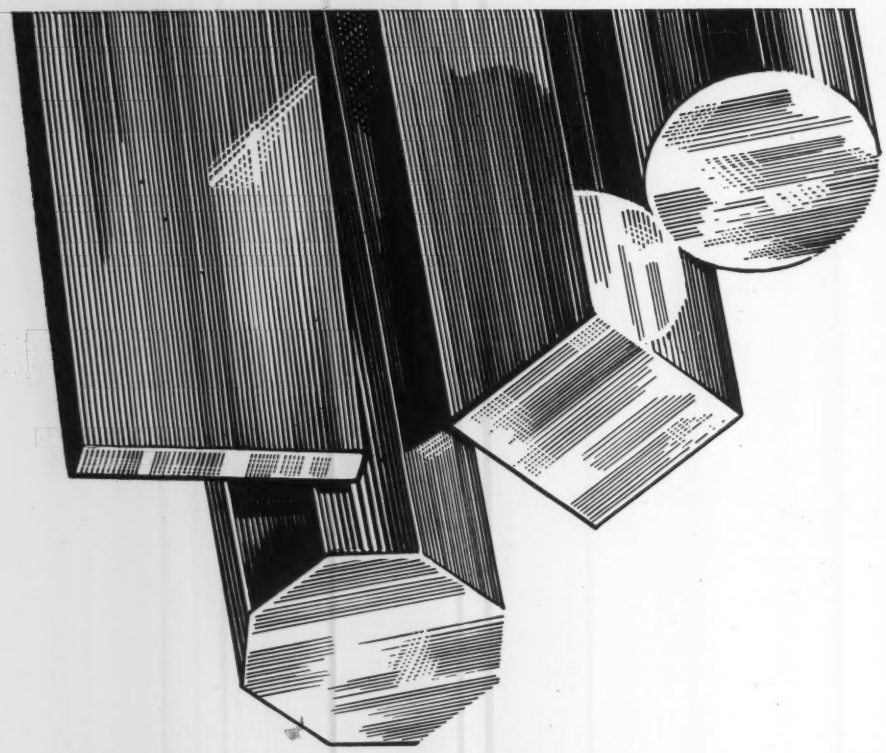
Your file should have this folder picturing and describing FORMSPRAG CLUTCHES. Write for it!

DISTRIBUTORS IN PRINCIPAL CITIES



23603 HOOVER ROAD • VAN DYKE, MICHIGAN

Your inquiries about Reinsprag and Cagedsprag Over-running Clutches are welcomed by the Formsprag Company.

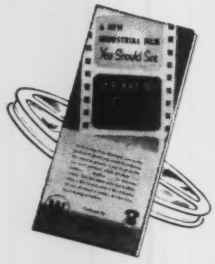


Big enough to serve you!

small enough to give you SPECIAL ATTENTION on

WYCKOFF

COLD FINISHED STEEL



FULL COLOR
SPARK TESTING FILM
AVAILABLE

This fast, inexpensive, non-destructive testing method identifies metals by analyzing the elements present. The film presents some of the fundamentals.

Address requests for showings to our general offices.

EXPERIENCE means not only length of time devoted to the refinement of a product but includes, as well, the diversity of product requirements solved. WYCKOFF, throughout its history, has specialized in the production of fine quality cold finished steels—in all commercial forms and for the broadest range of specifications.

SPECIALISTS IN COLD FINISHED STEELS EXCLUSIVELY

WYCKOFF STEEL CO.
General Offices: Gateway Center
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Works: Ambridge, Pa. • Chicago, Ill. • Newark, N. J. • Putnam, Conn.

WYCKOFF STEEL PRODUCTS: Carbon and Alloy Steels • Turned and Polished Shafting • Turned and Ground Shafting • Wide Flats up to 12" x 2" • All types of furnace treated Steels

Engineering Equipment

per second; for displacement, response is flat 5 to 1000 cycles per second. Made by **CEC Instruments Inc.**, Pasadena 15, Calif.

For more data circle MD-122, Page 211

Drafting Chair

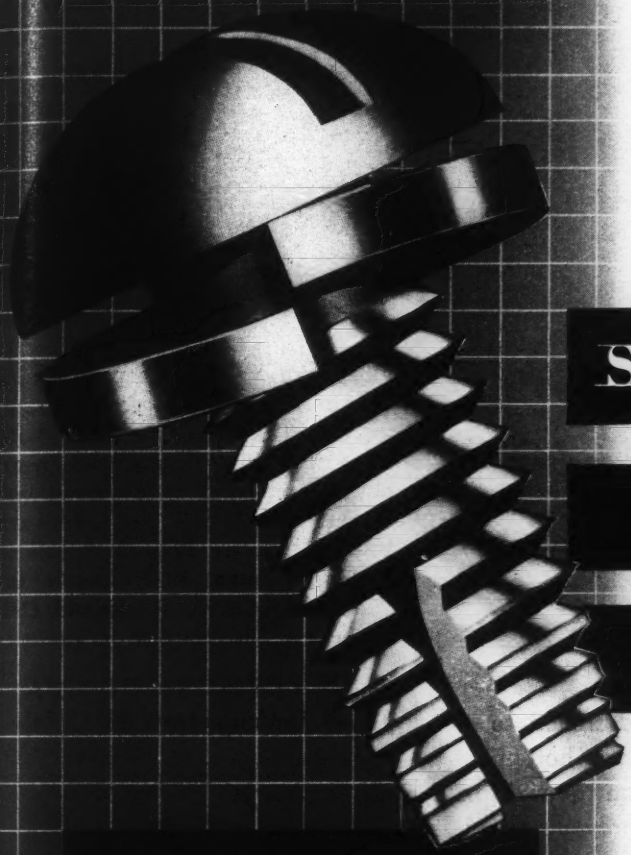
Improved Ajustrite drafting chair is available in seat heights which adjust from 20 to 28 in., 24 to 32 in. and 28 to 36 in. Height adjustments are made instantly by lifting the seat. Back rest has a two-way posture adjustment. The

2-in. thick rubberized hair and foam rubber seat, as well as the back rest, is upholstered in green, gray, black, brown or red U. S. Naugahyde. Made by **Ajusto Equipment Co.**, 2144 Madison Ave., Toledo 2, O.

For more data circle MD-123, Page 211

Double Pulse Generator

Model 4904 provides a source of single or paired pulses for testing electronic pulse circuits such as counters, gates, switches and amplifiers. The generator consists of two basic pulse-forming circuits which are triggered at a variable repetition rate by either an internal or an external frequency source, or by a manually operated switch. A time delay circuit pro-

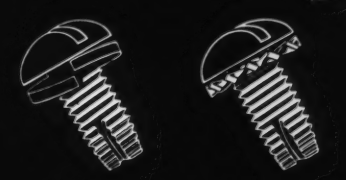


Eaton - Reliance Thread - Cutting

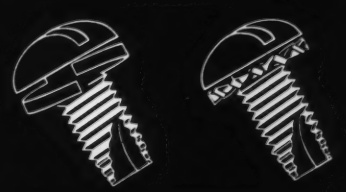
SPRINGTITES & SEMS

Fabricate Products

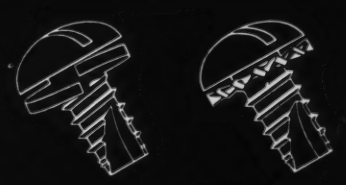
Faster at *Less Cost*



Type 1 for steel and stainless steel



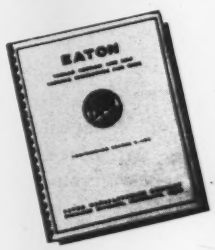
Type 23 for die-castings and light metals



Type 25 for Plastics

THE elimination of one expensive machining operation on the production line can sometimes mean the difference between profit and loss on a job. If you have a fastening operation which necessitates tapping, look into Eaton Reliance Thread-cutting Springtites and Sems. They are self tapping and actually tap as they fasten. It's all done in one operation wherein the clean, tightly seated threads don't have a chance to mis-mate or strip.

Your production people will find them easy to use regardless of the material. Manufactured with built-on helical or multi-toothed type washers, they are made for steel and stainless steel, die-castings and light metals, and plastics. Also available without washers. Many design engineers and production men are effecting great savings through faster production. For more detailed information write for our Engineering Bulletin S-49A. It's yours for the asking and of course, there's no obligation.



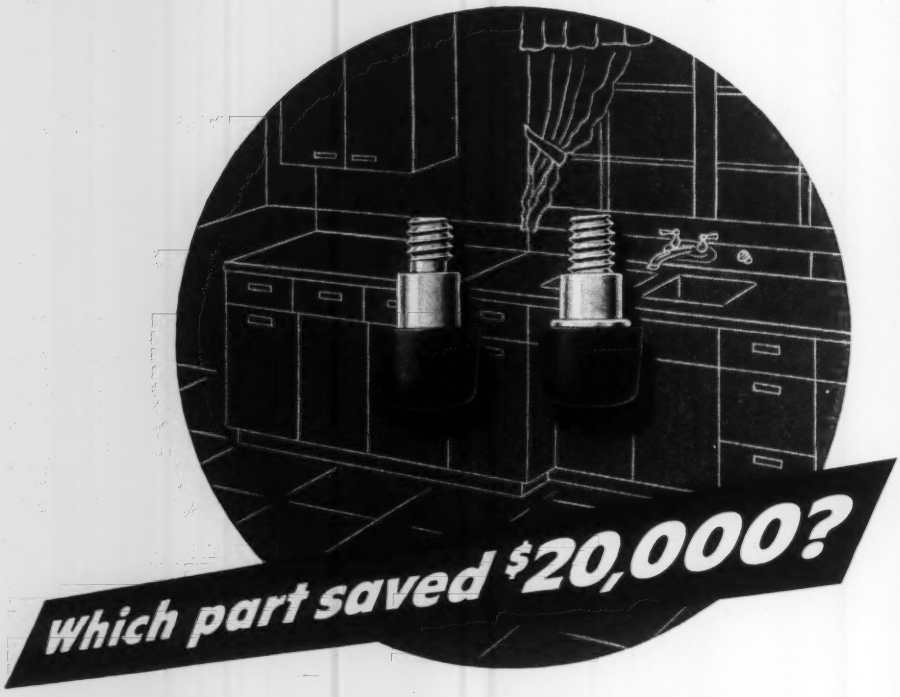
RELIANCE DIVISION

OFFICE AND PLANT: 1300 SOUTH ROSE ST., MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

EATON MANUFACTURING COMPANY

Springtites & Sems · Snap & Retaining Rings · Special Steels · Spring Lock Washers · Hoz-Fas-Ner



They're practically *look-alikes.* Both were designed to serve as rubber-tipped leveling screws on the bottom corners of metal kitchen cabinets. The part on the right does much the better job – its special collar prevents the rubber cap from slipping over the shank. Produced on COLD FORMING equipment, *it costs $6.00 less per thousand than the screw machine part previously used!*

Result: Savings of over $20,000 a year for one of America's leading makers of kitchen cabinets!

COLD FORMING and Good Design turned the trick!

Your annual investment for fasteners and small special parts is undoubtedly substantial in your plant. Savings that total thousands of dollars are not unusual when such parts are COLD FORMED without waste or scrap on high-speed automatic equipment and designed for high-speed automatic or semi-automatic application.

Thanks to long experience in COLD FORMING, Milford engineers, designers and product research experts are ready and able to help you cut small-parts costs substantially. They bring to your service Milford's leadership and know-how in the manufacture of semi-tubular, tubular and special rivets, as well as automatic rivet-setting machines.

So put us to work for you — on products you're making *now* or those you're *planning* to produce. Chances are we can help you make some major savings — in both *time* and *money!*

Write or phone nearest Milford Plant or Sales Representative!

THE MILFORD RIVET & MACHINE CO.

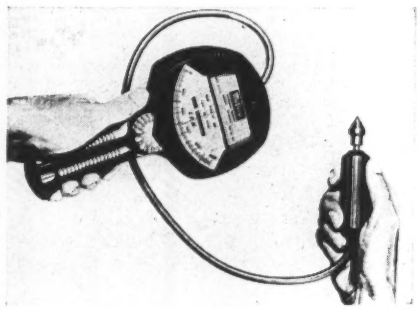
MILFORD CONN. | NORWALK CALIF. | ELYRIA OHIO | AURORA ILLINOIS | HATBORO PENNA.

Engineering Equipment

vides the variable separation between the first and second output pulses. The output of each pulse-forming circuit is obtained from a power amplifier which gives large output with small base-line variations. Made by Berkeley Scientific Div., **Beckman Instruments Inc.**, 2200 Wright Ave., Richmond, Calif.

For more data circle MD-124, Page 211

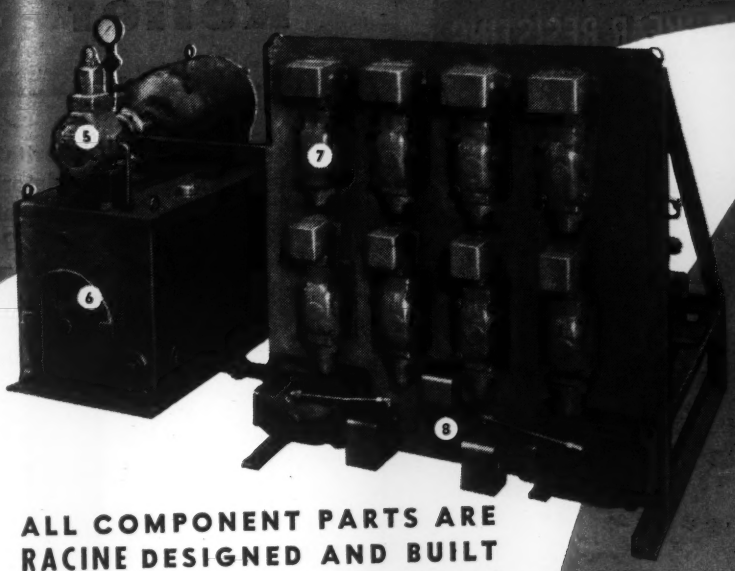
Hand Tachometer



Automatically changing the scale numbers for each speed range, a thumb-operated range selector on this instrument brings into view the correct number of revolutions per minute per scale division, eliminating the need to compute the scale markings for each range. The extra long scale is subdivided for better readability. Other characteristics are long life, low operating torque, rapid response, permanent lubrication and sturdy but lightweight construction. Commutated capacitor principle of operation prevents damage due to overspeeding or selection of the wrong range. A built-in calibration circuit provides a quick, positive check on performance. Different types of tachometers and range extending adapters are available for measuring speeds from 2 to 100,000 rpm. Made by **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo.

For more data circle MD-125, Page 211

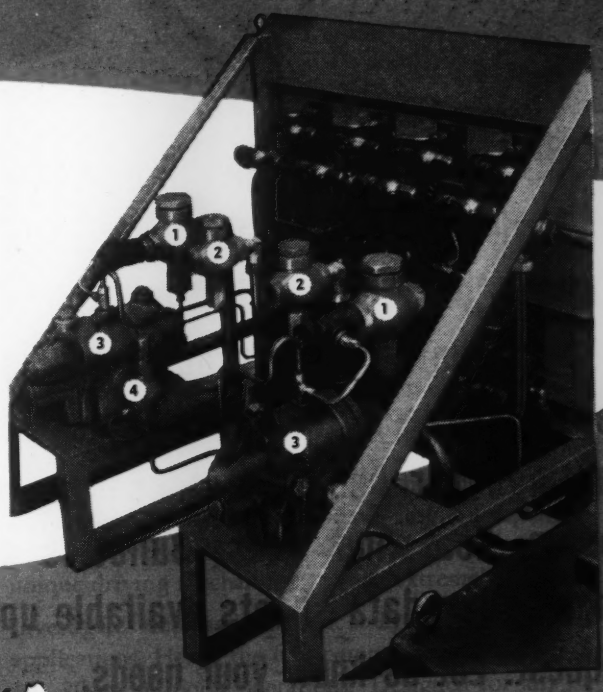
A Compact Hydraulic POWER HOUSE
one of many built by Racine for you . . .



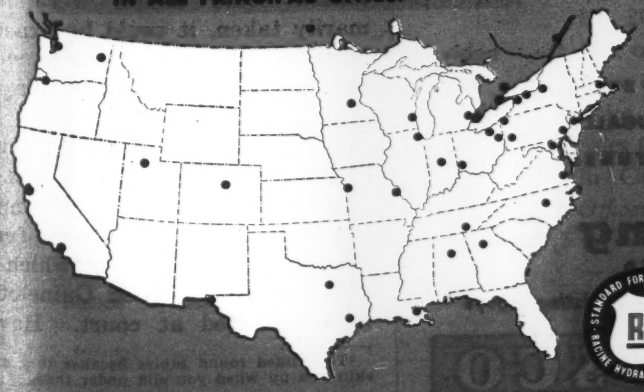
RACINE
Variable Volume
OIL HYDRAULIC PUMPS

ALL COMPONENT PARTS ARE RACINE DESIGNED AND BUILT
"They work better together"

1. RACINE Pilot Operated Check Valves
2. RACINE Free Flow and Throttling Check Valves
3. RACINE Pressure Boosters
4. RACINE Sequence Valve
5. RACINE Variable Volume Pump
6. RACINE Oil Reservoir
7. RACINE Solenoid Controlled, Pilot Operated 4-way Valve
8. RACINE Solenoid Operated 2-way Valve



SALES AND SERVICE REPRESENTATIVES IN ALL PRINCIPAL CITIES.

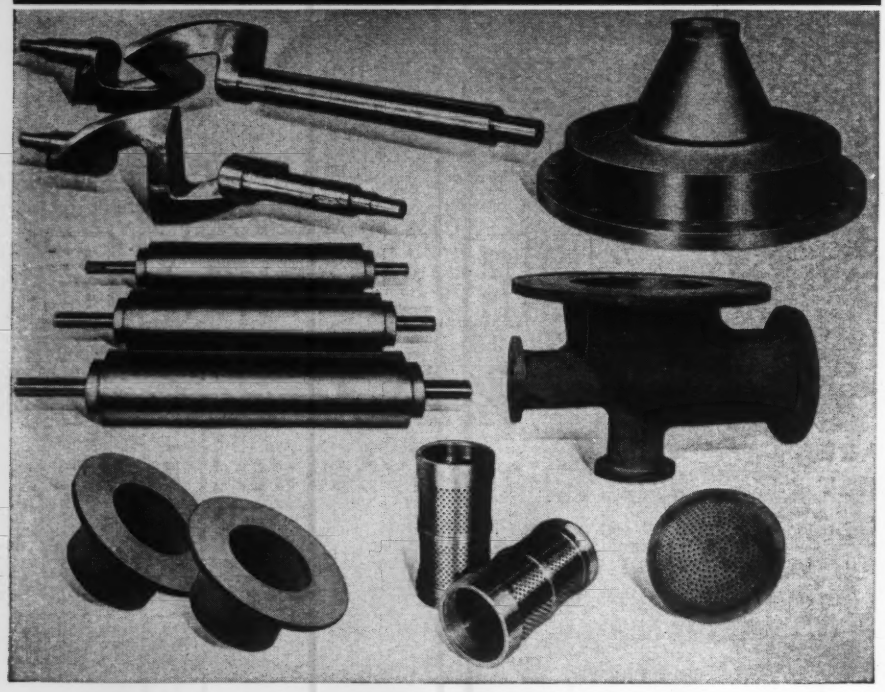


STANDARD FOR QUALITY AND PRECISION
RACINE
RACINE HYDRAULICS & MACHINERY, INC.

Racine Hydraulic Components Simplify any Hydraulic Circuit — "They Work Better Together." Write for complete Racine Hydraulic Catalog and the name of your nearest Racine Field Office. Complete Engineering Service Available. Address: RACINE HYDRAULICS & MACHINERY, INC., 2073 Albert St., Racine, Wisconsin, U.S.A.

MISCO *Stainless Steel* CASTINGS

CORROSION RESISTING · HEAT RESISTING · WEAR RESISTING



MISCO engineering, metallurgical and production facilities are at your service. We are pleased to furnish specific information on the proper analysis, design and application of stainless steel castings for best resistance to corrosion, heat and wear. Bulletins and engineering data sheets available upon request. Let us know your needs.

LARGE AND MEDIUM WEIGHT STAINLESS STEEL CASTINGS • CENTRIFUGAL CASTINGS • CENTRIFUGALLY CAST STAINLESS STEEL PIPE AND TUBES

Michigan Steel Casting Co.

DIVISION OF EBALOY, INCORPORATED

One of the World's Pioneer Producers of Heat and Corrosion Resisting Alloys

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MISCO
Heat and Corrosion Resistant Alloys

Stress Relief

CONTINUING his authoritative accounts on the historical sources of engineering or technical terms so common today, Gene Murphy of Minneapolis-Honeywell went back through many centuries to uncover this possible origin of a quite versatile machine element.

Idlers of the King

In the vicinity of Camelot during the days of the good King Arthur, there once dwelt a maker of tables, by name Launcevere Q. Guinelot. Being an artificer of great skill, having indeed constructed the Round Table of which the noble Pendragon and his knights were so proud,[1] his services were in great demand, and he was greatly loved by all save one.

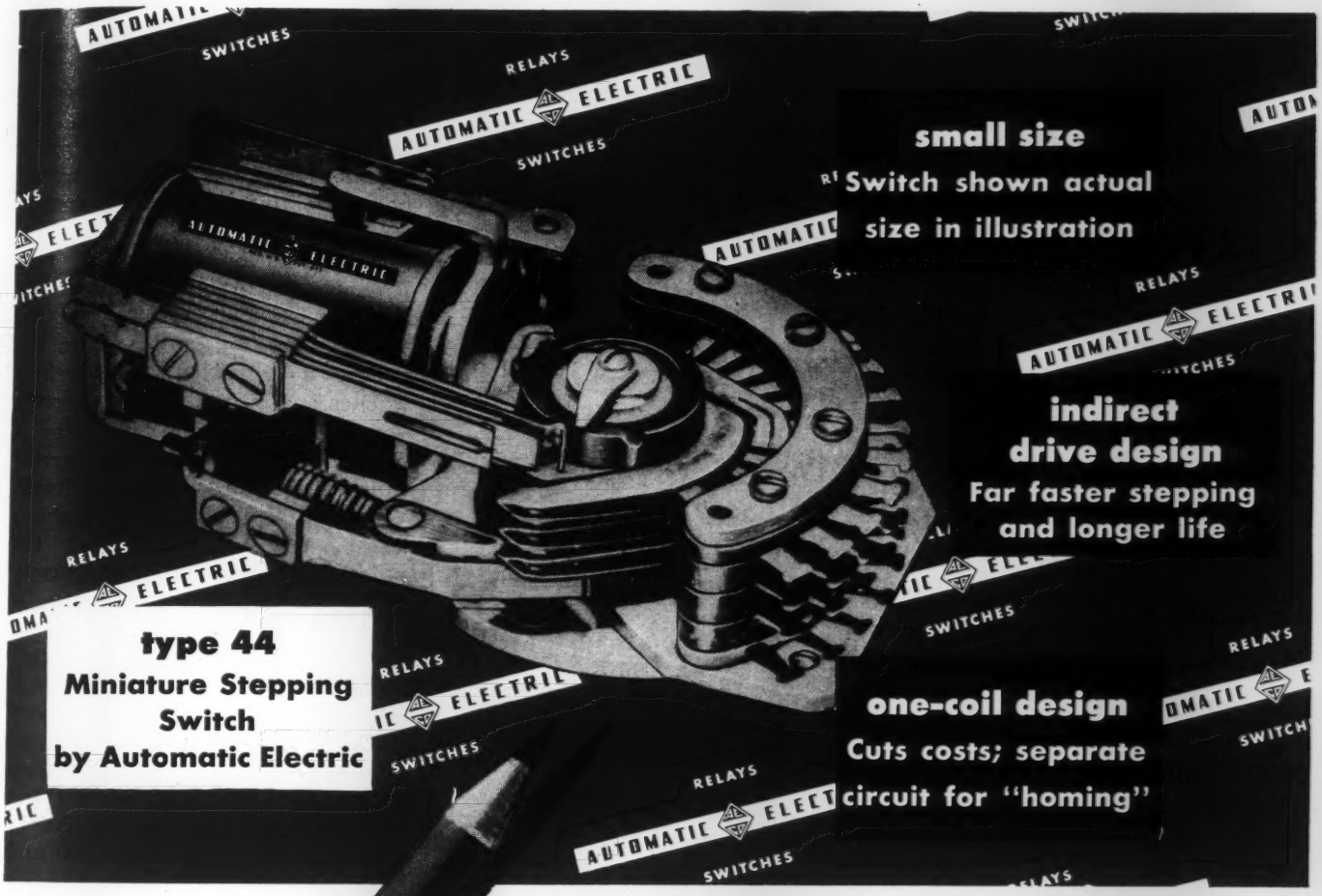
That one, a knave called Beowulf, was also a maker of tables but contended that round tables were in a deplorable state of obsolescence and should be replaced straightway by square ones. Needless to say, his arguments found little favor with the nobility so long as King Arthur retained his liking for the Round Table. In fact, he had been forbidden by royal proclamation to set foot inside the palace.

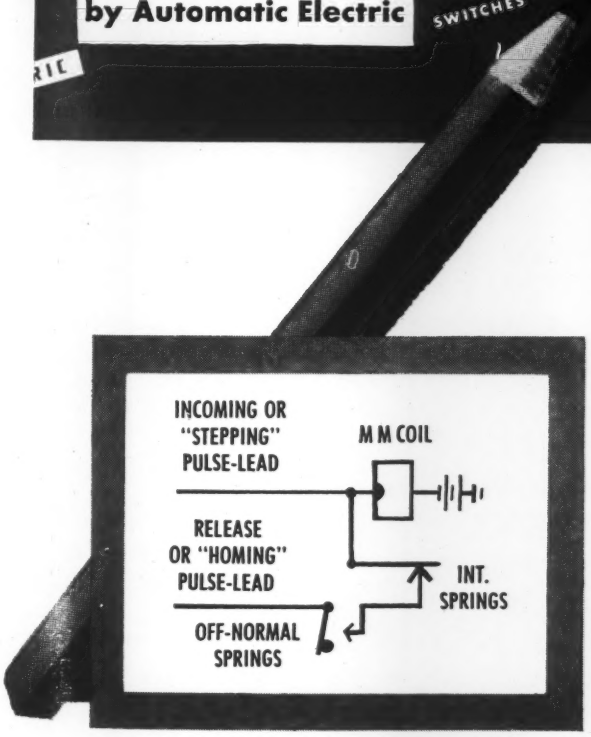
Now, haplessly, this Beowulf had constructed square tables in such numbers that his inventory had become dangerously high, and unless some action were summarily taken, it could be expected that his board of directors would demonstrate with him, mayhap even to the point of flinging him into one of the many readily available dark and dank dungeons.[2]

Such being the case, it was to his better interest to devise forthwith some method by which he could cause the good Guinelot to be discredited at court. Having

[1]They liked round tables because they didn't skin you up when you slid under them.

[2]If he could have afforded an electronic accounting machine he may have avoided this.





How separate "homing" circuit is provided with one-coil operation

Interrupter contact springs open coil circuit near the end of each armature operation—causing switch to step by self-interruption, or by "door buzzer" action.

"Off-normal" contact springs close "homing" circuit on first step of wipers off home position and remain closed until home position is again reached. Thus, after the first step, a "homing" circuit is prepared, and the switch may be "homed" by simply energizing this circuit.

How to make a good product better...without increasing costs

Design engineers everywhere are choosing Automatic Electric's Type 44 Miniature Stepping Switch to insure long service life—often *reducing* costs as they do so! In countless applications, this sturdy switch has operated for more than 200 million operations, with little or no adjustment. The one-coil design eliminates a separate release coil—a saving passed on to the user.

And there are other reasons for such widespread approval: weight and space are saved; indirect drive design give smooth stepping and because there's no wiper "double loading" there's no "galloping"; the unique driving mechanism permits extremely high operating speeds.

Investigate Automatic Electric's Type 44 Switch for your control applications. Here's the first compact, lightweight switch to provide 10-, 20- or 30-point operations. Designed for any dc voltage up to 110, or, with an associated rectifier, for 115 volts 60 cycle ac. For more details on this and other Automatic Electric stepping switches, write for helpful engineering specifications to: Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois. In Canada: Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

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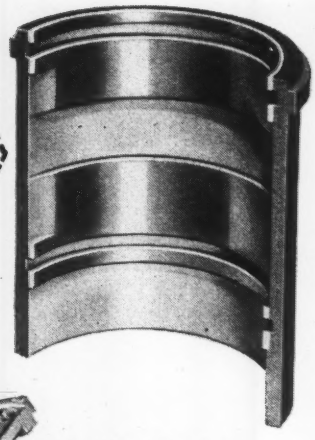
Babbitt and Backing are ONE



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Perfect bond between babbitt and backing remains unbroken in this babbitt-lined, steel-backed bearing flattened under terrific pressure.

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Special preparation of the backing, by the Kolene process . . . plus the most advanced practices in centrifugal casting, under precision control . . . results in an actual chemical bond (metal-to-metal fusion) between babbitt and backing which eliminates the need for anchor slots. Uniform crystalline structure of the babbitt, resulting from this method of centrifugal casting, assures maximum fatigue resistance and long life for Waukesha Bearings of any design, under heavy pressure or shock loads.

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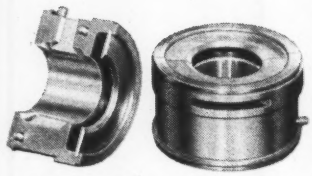
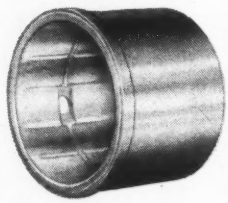
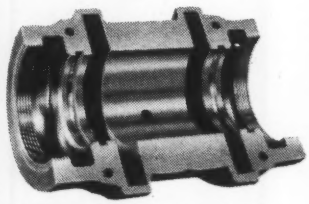


A Waukesha Split Bearing for use in high speed turbines.



Waukesha Sleeve Bearing for heavy duty compressors in almost constant use.



A Waukesha bearing of complex design for a widely known manufacturer of generators.

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Stress Relief

in his employ an owl named Francois, who, while young, had been trained to talk by the great Merlin, Beowulf deemed it advisable to obtain some much needed advice.

"The solution is simple," said Francois, scratching himself absent-mindedly. "Tomorrow at the ninth hour, Guinelot brings to the palace a cart load of flytherwyckes.[3] You have but to secrete yourself aboard the cart after it has been loaded, and be carried thus within the very palace itself. With you, you must bring a sharp knife, and upon reaching the palace, you must go straightway to the Round Table and carve it into a square shape.

"About Arthur and his knights you need not worry, for there is much talk of a dragon of sorts in the Royal Forest, and they will be ahunting it. Immediately they return and see how fine a thing is a square table they will sing the praises of your tables and your inventory will vanish like fog in a fire."

"You have spoken wisely," said Beowulf, "and for that you may have these six fat mice that I have been saving this past fortnight for my cat, Grundoon.[4] I will go and do as you say!"

And so it came about that on the morrow at the eighth hour, Beowulf climbed aboard the cart of Guinelot and hid himself among the uppermost row of flytherwyckes, taking up such a position that he could if necessary, raise his head above the load much in the manner of a turtle.

When the cart had moved along some leagues it stopped, and Beowulf raised up to look about him. The wheels of the cart were of wood, and the road was rough and rutted; as a consequence, Beowulf, aching in bone and muscle, was too concerned with his own misery to wonder why they had not yet reached Camelot.

At last his pains subsided somewhat and he saw Guinelot off to the side of the road preparing his lunch—a fat fowl over a crackling

[3]These were used by various people for numerous purposes. They were made of oak.

[4]Grundoon thought this highly unethical since he had caught the mice in the first place.

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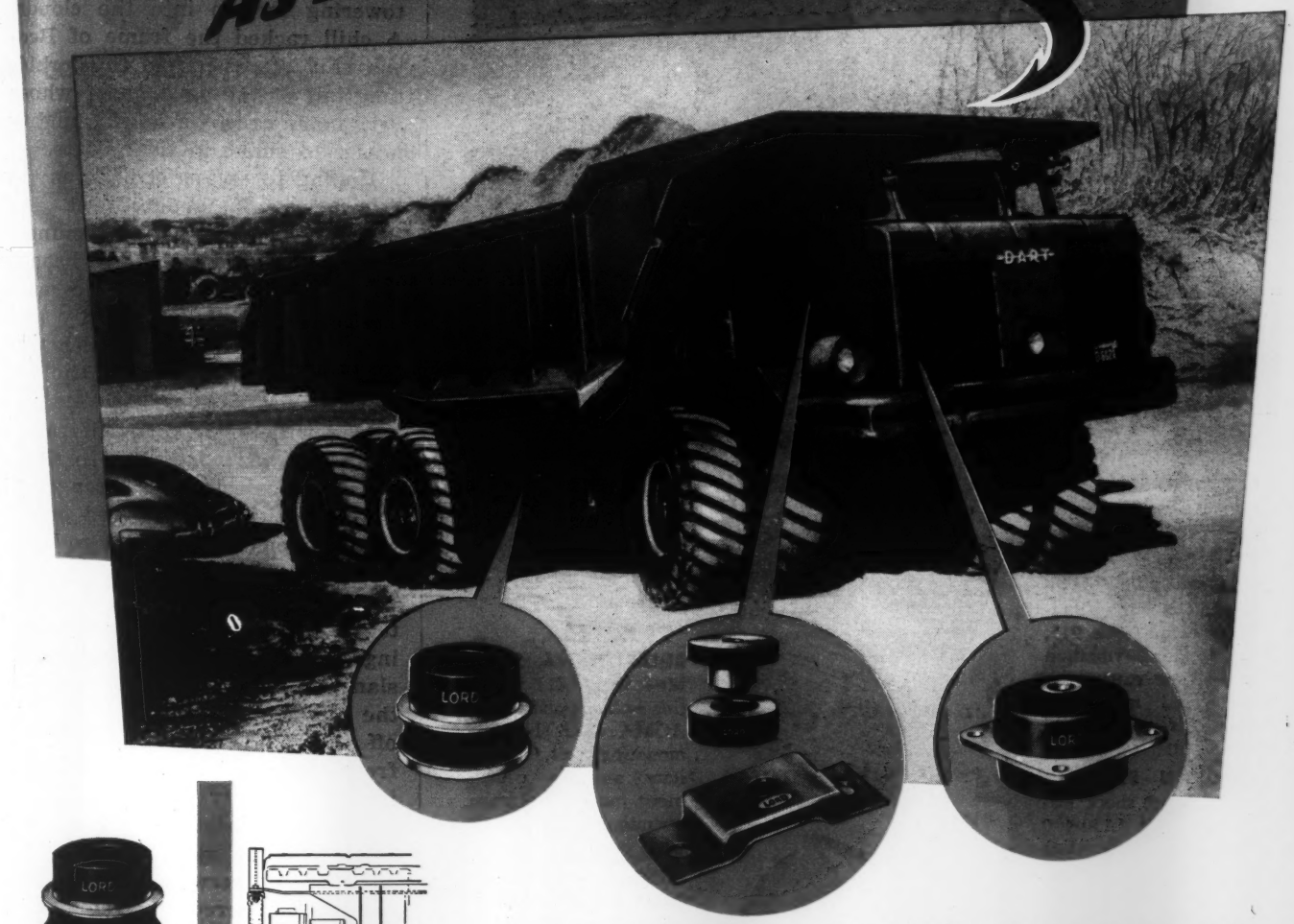

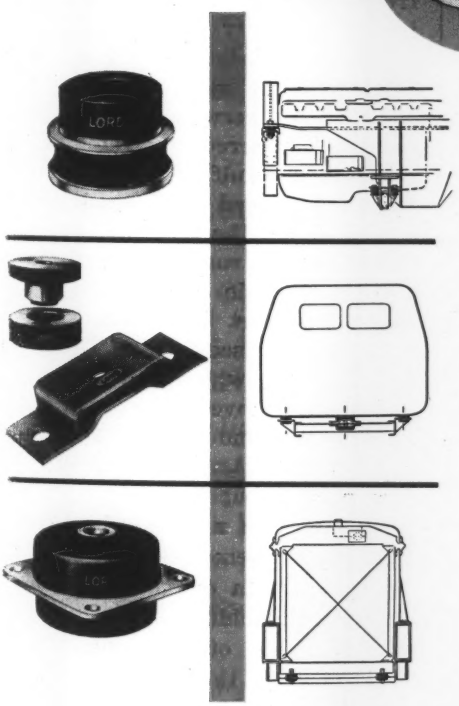

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fire of small sticks. He saw, too, that the scenery thereabouts in no way resembled the palace at Camelot.[5]

Ahead of them the road vanished into a yawning tunnel that pierced the base of a grim castle towering far up into the clouds. A chill racked the frame of Beowulf for he recognized the forbidding lair of the ogre Sexat, whose very name caused even the mighty nobles to shake in their boots.[6]

Hoping to escape ere it was too late, Beowulf shouted at the horses who were placidly munching grass, but these poor beasts, being sore affrighted, came madly to life and plunged wildly into the tunnel, the roof of which was just high enough to clear the uppermost row of flytherwyckes.

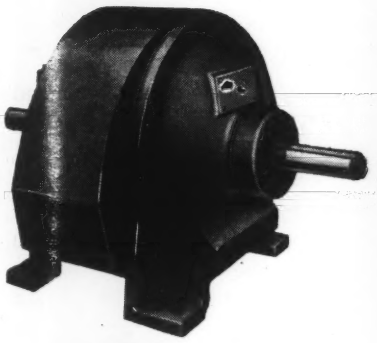
Mad with panic, Beowulf raised his head and commenced to shout "Camelot" with all his strength in the hope that the frenzied beasts would perchance stop and go back. But they only ran the faster, and, what was still worse, the cart took up a mad hopping and bumping motion that repeatedly slammed Beowulf's head against the tunnel roof, each time clipping off the last two syllables of his frenzied cry, and eventually silencing him forever.

When Guinelot and Sexat had settled on the matter of payment for the flytherwyckes, and had carefully interred the remains of the late Beowulf, which they had found scattered here and there among the flytherwyckes, they sat down over a roast ox to discuss the manner in which the poor knave had met his death.

"I cannot see," said Guinelot perplexedly, "why my cart, which has always moved back and forth, should, of a sudden, also move up and down. Are you sure you cast no spell upon it?"

"I have cast no spells in a fortnight," answered Sexat, picking up the cart in one hand and examining it, holding the horses the while in his other hand. "But look now at these wheels which should be round. They are, for

[5]Francois had given him a bum steer.
[6]This guy still bothers people every March.
[7]Poor Sexat got blamed for everything.



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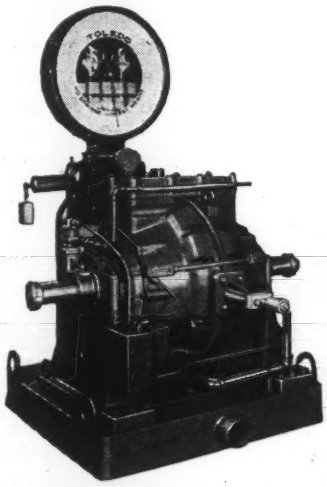

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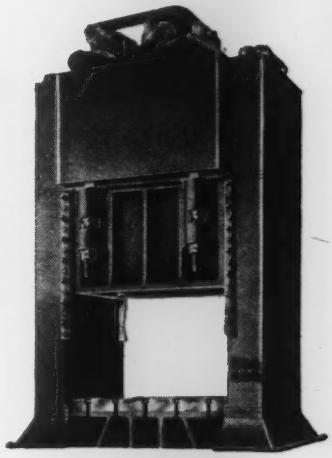
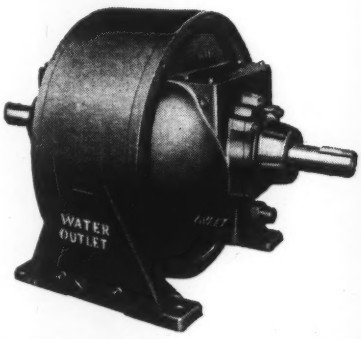
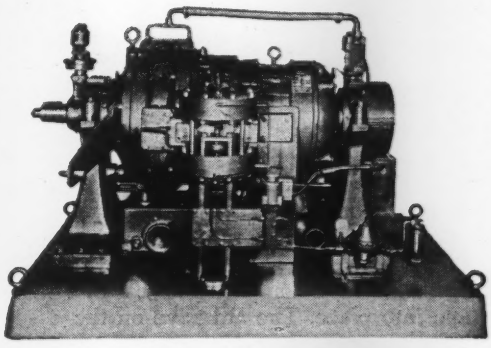


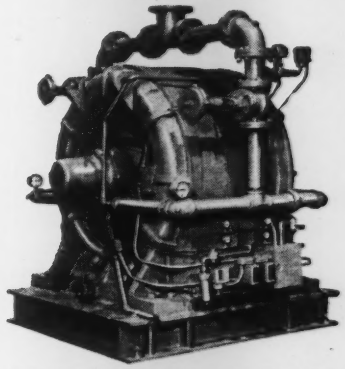
PRESS DRIVES



LIQUID COOLED COUPLINGS



UNIVERSAL DYNAMOMETERS



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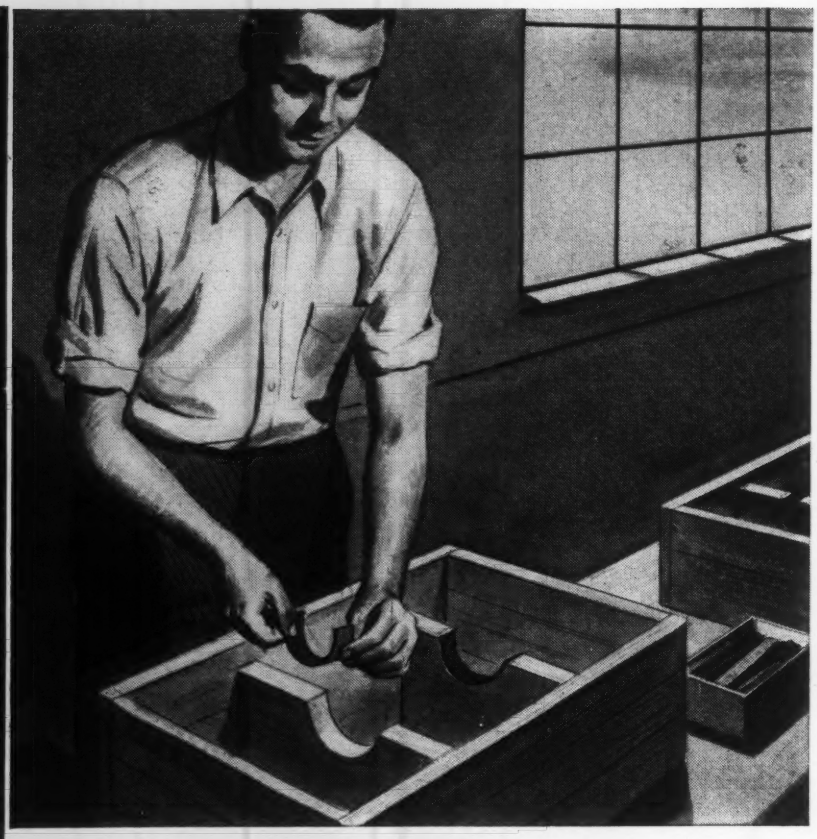

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You can prevent breakage and scratching in shipment by putting strips of Armstrong's DK-153 Tape at all points of contact between the packing case and the items to be shipped.

This unique cork-and-rubber tape provides effective cushioning against the shocks and jars of transportation. In addition, the smooth, high friction surface can't scratch highly machined parts or damage painted finishes.

It takes only seconds to apply DK-153. You just peel off the cloth backing and press the tape into place. The adhesive on the back sticks to almost any clean, dry surface.

DK-153 has thousands of uses: as a stick-on gasket for incubator doors; as a rattle deadener in bus bodies and fenders; as an anti-skid cushion on furniture and office machinery. The tape is available in a variety of widths and thicknesses, and in sheets, rolls, ribbons, or die-cut shapes.

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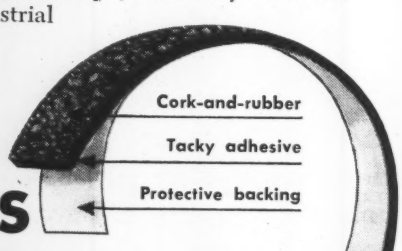

ARMSTRONG'S

DK-153 TAPE

Stress Relief

some reason or other, shaped more like pears."

"Oh, that!" said Guinelot, "while I was eating my lunch your wood-eating Mastiffs, Nyp and Tuck, stopped by and lunched on my wheels. Since they are somewhat more than twice my size, I thought it best to leave them be. Think you then that this could have something to do with what we speak of?"

Now all his life Sexat had wanted to be a scientist and he was excited at this which he had found. "By so changing the shape of the wheels," he exclaimed, "we have produced a contrivance which can take a going-around thing and turn it into an up-and-down thing.[8]

This is indeed a great discovery and we must have a name for it."

"Since, save for Beowulf, we would never have discovered it, let us name it that which he shouted while in the tunnel," suggested Guinelot.

"To me, that sounded like 'cam'," said Sexat.

"To me, also, it sounded like 'cam'" said Guinelot, "so let us call it 'cam'. It is a silly name and doesn't make much sense, but then, some day, another, even wiser than us, will rename it, so why should we waste our time thinking up a better one!"

But, for one reason or another, no wiser one appeared, and to this day certain gadgets that change rotational motion into reciprocating motion are called cams.

[8]A destroyer in a rough sea can also do a certain amount of this.

They Say . . .

"The engineer . . . has to have a plan to set a goal, establish a target; a goal to encourage him to put aside the newspaper and get to work in the morning—to stop gossiping—to encourage him to spend the energy required to think. If a factory worker comes in with a hangover, the machine paces him; he either keeps up or goes home. The engineer can sleep and look intelligent."—E. G. UHL, *vice president, engineering, Glenn L. Martin Co.*

Meetings

AND EXPOSITIONS

Feb. 15-17—

American Management Association. Personnel conference to be held at the Palmer House, Chicago, Ill. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 18, N. Y.

Mar 2-4—

Society of Automotive Engineers. National passenger car, body and materials meeting to be held at Hotel Statler, Detroit, Mich. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Mar. 4-5—

American Society for Metals. Midwinter meeting to be held at Hotel Statler, Boston, Mass. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, O., is managing director.

Mar. 8-12—

National Electrical Manufacturers Association. Midwinter meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. W. J. Donald, 155 East 44th St., New York 17, N. Y., is managing director.

Mar. 15-19—

National Association of Corrosion Engineers. Tenth annual conference and exhibition to be held at the Kansas City Municipal Auditorium. Additional information may be obtained from society headquarters, 1061 M & M Bldg., Houston 2, Tex.

Mar. 16-17—

Steel Founders' Society of America. Annual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 920 Midland Bldg., Cleveland, O.

Mar. 17-19—

Pressed Metal Institute. Spring technical meeting will be held at

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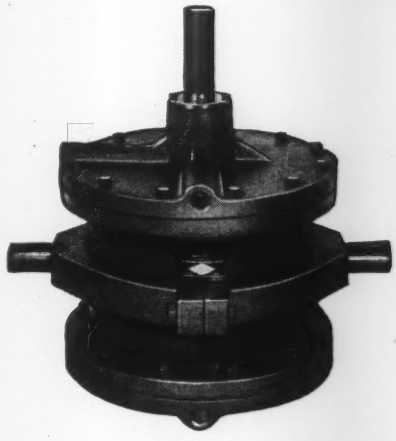

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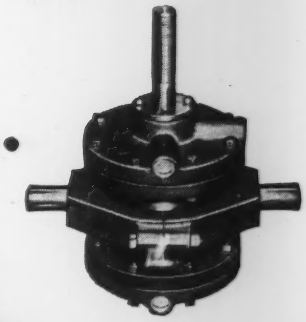

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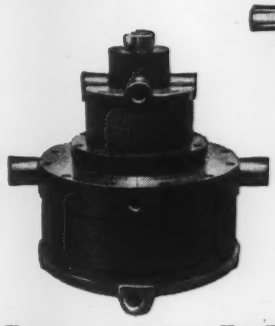

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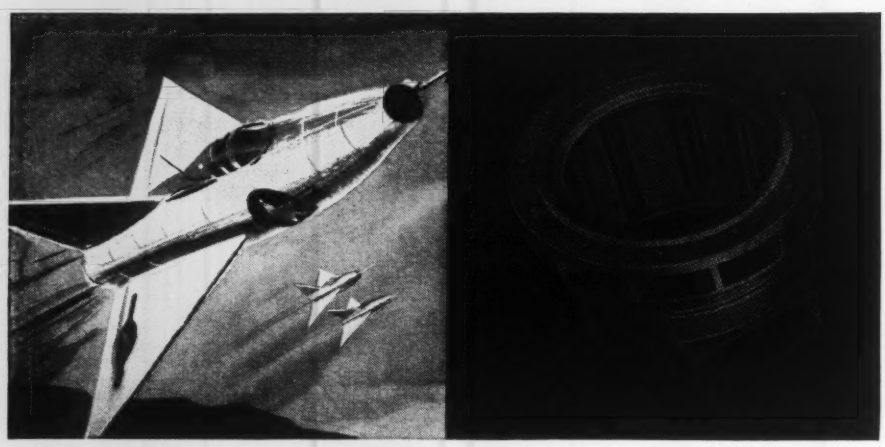

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Meetings and Expositions

Hotel Carter, Cleveland, O. O. B. Werntz, 2860 East 130th St., Cleveland, O., is managing director.

Mar. 22-25—

Institute of Radio Engineers. National convention to be held at the Waldorf-Astoria Hotel and the Radio Engineering Show at Kingsbridge Armory in the Bronx. Additional information may be obtained from society headquarters, 1475 Broadway, Times Bldg., New York 36, N. Y.

Apr. 3-4—

Packaging Machinery Manufacturers Institute. Spring meeting to be held at Hotel Dennis, Atlantic City, N. J. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

Apr. 5-7—

National Fluid Power Association. Spring meeting to be held at the Edgewater Gulf Hotel, Edgewater Park, Miss. Barrett Rogers, 1618 Orrington Ave., Evanston, Ill., is executive secretary.

Apr. 14-16—

Society for Experimental Stress Analysis. Spring meeting to be held at the Hotel Netherland Plaza, Cincinnati, O. W. M. Murray, P. O. Box 168, Cambridge 39, Mass., is secretary.

Apr. 26-28—

American Management Association. Manufacturing conference to be held at the Hotel Statler, Cleveland, O. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 36, N. Y.

Apr. 26-30—

American Society of Tool Engineers. Convention and industrial exposition to be held at Bellevue-Stratford Hotel, Convention Hall and Commercial Museum, Philadelphia, Pa. H. E. Conrad, 10700 Puritan Ave., Detroit 21, Mich., is executive secretary.

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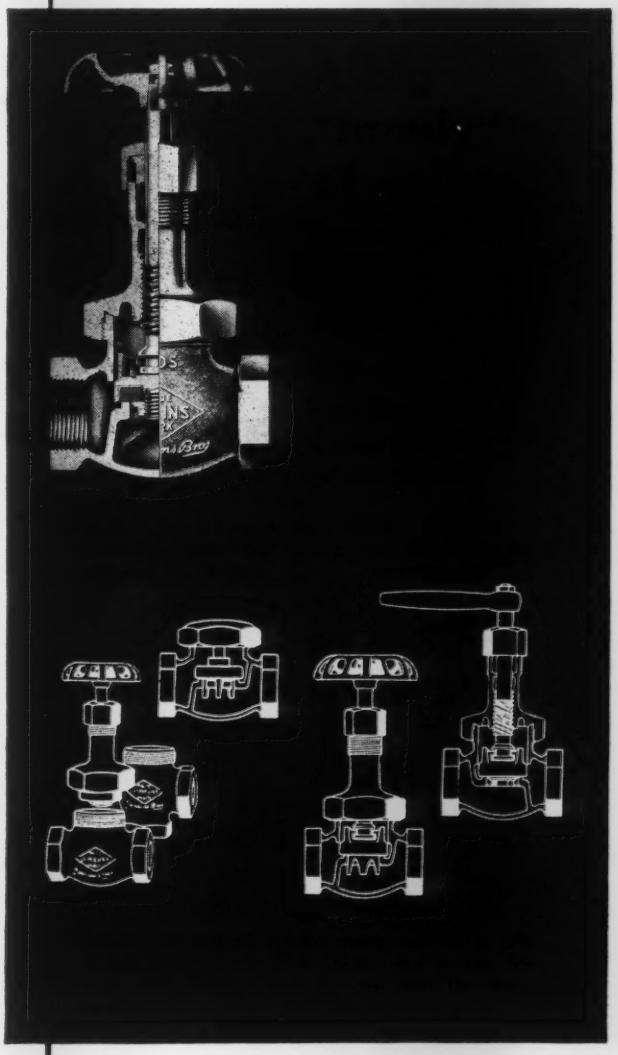

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Technical Journalism

. . . its contribution to engineering progress

By J. Foster Petree
Editor
Engineering
London, England

DESIGN ABSTRACTS

THERE is a legend that a new periodical once appeared in which the initial leading article announced with refreshing candor that "This journal has been established to meet a long-felt want, namely, a comfortable competence for the proprietor." Almost certainly it was not a technical journal—they deal with practical men and do not need to labor the obvious; but it is sometimes a little difficult to convince the readership of a technical journal, especially one with a circulation that is largely industrial or commercial, that financial considerations may not be the sole motive governing its contents, its expressed opinions, or, on occasion, its omissions. This should be evident enough from the elementary fact that, while it is possible to run a paper that has readers but no advertisers, it would be quite impracticable to maintain one that had advertisers but no readers.

". . . the technical journal should be in a position to take an independent line on matters of technical controversy, without regard to purely commercial influences."

This is fundamental, but it is not always appreciated. In the case of technical periodicals the problem of ascertaining and evaluating the relative positions of the reader, the advertiser, and the scientific, professional, and industrial publics which are their background is one of considerable complication. This problem is made still more complex by the economic trends of recent years.

There can be few publishers or editors of long-established technical journals who, turning over the pages of their earlier volumes, have not envied the relative simplicity of technical publishing as their predecessors knew it even a mere half century ago. Those halcyon days have gone but it is permissible to wonder whether the changing circumstances are really understood as widely as they might be; and indeed, whether the functions that the technical press can and should exercise are properly appreciated by those who ought to benefit most by them.

Technical Journalism: In the first place, how is one to define the "technical" press as distinct from the scientific and the frankly "trade" publications? Comparison with the world of newspaper and magazine publishing is of little help, for that is a different field altogether. It is possible, perhaps, for a newspaper man to learn to pull his weight on a trade paper, especially one dealing with consumer goods, but he would be hopelessly at sea if he joined the editorial staff of a scientific or technical publication. The pure scientist or mathematician would also find himself at a loss, though to a less extent, in the field of the technical journalist, who must have a firsthand acquaintance with industrial affairs as well as with technology.

". . . main function . . . includes making available to the engineer, as widely as possible and with due discrimination, the experience of others in his own and related fields."

My own definition of a technical journal is one that maintains an editorial staff of men whose training has been primarily technical and who are competent to discuss with their readers and contributors on reasonably equal terms the technicalities of the field with which the journal purports to deal. It is important that the technical journal should be in a position to take an independent line on matters of technical controversy, without regard to purely commercial influences. This last is often a hard condition to meet, but a reputation of that sort is an asset not to be relinquished lightly.

This definition or yardstick has no official backing from any publishers' association or other authority; it is a purely personal attempt to lay down a line of gen-

eral demarcation. Obviously it is less precise than might be desired but precision in this matter is peculiarly difficult to attain because many periodicals do not fall definitely into one category or another. There are even some which appear to fluctuate in their allegiance at different periods. Many engineers, however, seem to have such a vague notion of what they mean when they refer to the technical or trade press that the broad division may serve to clarify their ideas.

Service Function: In considering the present and future position of the technical press in relation to industry, it is desirable first to consider what functions a technical journal should discharge. These functions may include:

1. Presenting current news of technical progress.
2. Reporting events of technical interest.
3. Sifting, discovering and translating reports of such progress in foreign publications.
4. Reviewing technical books.
5. Providing informed comment and the opportunity for readers to comment also—thus helping to mold technical opinion.
6. Providing advice and special information when this is asked for.

The manner in which these functions are discharged naturally varies between one function and another, according to the facilities available. It varies between one publication and another according to the order of precedence in which those who conduct the journal place the several functions. Moreover, changing patterns of the engineering profession and industry in the course of years may lead to a gradual shifting of emphasis. For example, journals of 50 years ago printed countless letters and queries from readers to which no editor today could afford to devote a corresponding amount of space; yet he might feel justified in filling that space with expensively produced illustrations, even though their presence might not be essential to the accompanying text, because that is what the reader of today expects and often illogically desires.

Broadly speaking, therefore, the main function of the technical press is educative. This includes making available to the engineer, as widely as possible and with due discrimination, the experience of others in his own and related fields. The latter is particularly important at the present time, when developments in one direction, such as metallurgy or electronics, may be the key to advances in many other fields. After all engineers learn their art and science almost entirely by experience—their own, that of their predecessors, and that of their contemporaries. The utility of personal experience is obvious. The experience of predecessors is largely, though not wholly, available in appropriate textbooks.

However, textbooks cannot begin to present on any comprehensive scale the most recent experience and the hopes, ideas, ideals, deductions, and sometimes fanciful notions of contemporaries which may have such a valuable formative effect on the development of each engineer's thoughts and ambitions. For information of that kind, the engineer must rely on the periodical literature of his subject, comprised of the published transactions of societies, the reports of organized research, and the technical press. For many working in areas far removed from libraries and institutions, the technical press is the accepted guide to the other two.

In the nature of things, textbooks are always out of date to some extent, if only that of the time needed to prepare and produce them. It is absolutely impossible to revise them quickly enough to keep pace with the growth of knowledge. Books which deal with basic principles can be relied upon to retain some permanent value, but their presentation may be obsolescent even if their fundamental matter is not. In any case, however, books of this kind, while essential to the student, are not so much used by the engineer in his later and really productive years. What he needs are the results of actual practice, and for that he must go to the periodical literature. Of course this is one of the main sources from which new textbooks are compiled as may be seen from the long lists of references usually to be found in them. Parenthetically, it may be remarked that a spell on the editorial staff of a technical journal, to be spent in extracting and condensing the essentials of these learned dissertations, might be of considerable benefit to those who contemplate adding to their number.

Industry's Attitude: What is the attitude of industrial personnel toward the technical press? Are they getting all that is required from it or all that it has to offer? Or are these personnel rather inclined to take the technical press for granted as one does a daily newspaper without stopping to consider that it needs the interest and co-operation of industry not solely in the form of buying advertising space? The principle of conservation of energy has its analog in many other directions, and what a man gets out of the technical press must depend to a great extent on what he, as representing the engineering and associated industries, puts into it.

"The value of the technical press to engineers is a function of the use that they make of it, the knowledge that they bring to their reading, and their capacity to appreciate the variety and quality of the vast stores of technical information . . . in its pages."

" . . . an editor cannot invent facts; he can only examine, appraise, compare, arrange and, as may seem desirable, emphasize them."

Design Abstracts

The value of the technical press to engineers is a function of the use that they make of it, the knowledge that they bring to their reading, and their capacity to appreciate the variety and quality of the vast stores of technical information and critical comment that are contained in its pages. It may seem at times to be in competition with publications of the learned societies, but in fact that is not so. It is complementary to them, and a careful study of both is necessary if a true picture is to be obtained of the complex intermingling of science and practice that is the engineering industry of today.

If engineers and industrialists set themselves to consider what they really want from the technical press, each and every one will arrive at the same conclusion. They want facts and it matters very little whether articles are presented in plain black and white or with splashes of color and artful typography that tends today to overflow from advertising pages into the editorial text. Professional societies, which expect their publications to be taken seriously and read conscientiously, usually do not employ these costly eye-catching devices, or accept the advertising man's favorite argument that the top-ranking executive has no time to read columns of type, but must be enabled to grasp the whole story in a flash by merely flipping over pages and glancing at headings and illustrations. In this vein the top-ranking executive probably doesn't read the advertisements either, but if he knows his job he will have people on his payroll who read the whole issue from cover to cover, knowledgeably and critically.

" . . . the technical press has gone far . . . to fill gaps in the records of technical achievement, and often to promote further advances . . . "

It is to these men that the executive will turn when he wants a specific answer to some technical question, and it is to them that editorial matter should be primarily addressed. These are the people who seek out the facts to present at the right time. But an editor cannot invent facts; he can only examine, appraise, compare, arrange and, as may seem desirable, emphasize them.

It is obviously desirable, therefore, that the editor should be able to meet directly executive heads of firms and organizations in his particular field, whenever he has occasion to do so. As a general rule he can and does, but that is not enough. It is eminently desirable also that those executives, technical and administrative alike, should appreciate what he requires and, busy men though they are, should be prepared to devote some personal attention to ensuring that he gets the facts that he is seeking.

Industry's Responsibility: With the growth of big scientific and industrial organizations, and the wide spread of their activites, supplying the facts is becoming steadily more difficult to ensure. Hence the modern tendency has developed to lump together all press matters, editorial as well as advertising, under the general heading of "publicity" and to hand them over to a middleman, either a member of the firm's staff or an outside advertising agent.

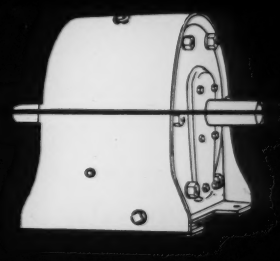
In the former case, this may work smoothly enough if the staff man is technically trained, is of sufficient standing within the firm to have ready access to everyone of importance, and has the requisite knowledge of technical journalism to realize what is wanted and that what may serve for one journal may not suit another. Where those conditions are not satisfied, however, this middleman may with the best intentions in the world become a barrier to effective liaison; or, worse still, to come to regard himself and to be regarded by his superiors as having been put there as a barrier to protect scientific and industrial organizations against the importunities of too-pertinacious press men.

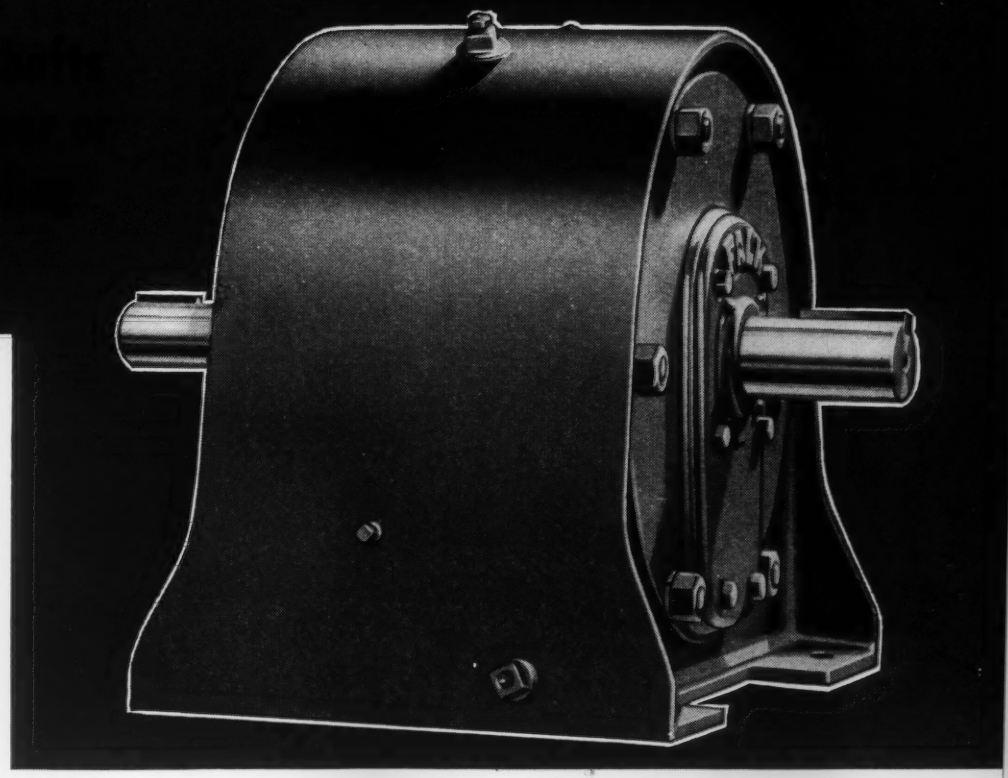
" . . . the technical press "The prime function of the technical press must be educational in the truest and widest sense of that sometimes misapplied word."

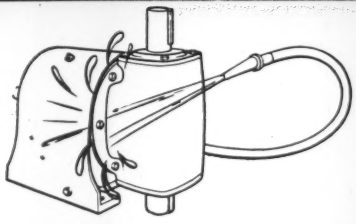
Too often, also, the outside man, whose interests probably lie mainly in the buying and filling of advertising space, it is liable either to become a mere "post office" relaying queries to his client and transmitting their replies or else to concentrate on obtaining the maximum number of "mentions" without much regard to their technical worth. There are notable exceptions, to whom should be paid tribute, and they flourish deservedly; but, in almost every instance, they are men who have had some technical training.

The heads of engineering firms and scientific and research organizations would do well to consider the advisability of separating purely advertising activities from the direct distribution of technical information. They should devote some part of their time to personal collaboration with the editorial departments of the particular journals interested in their work and products. Assistance should be given to the editors of those publications to make articles sources of such permanent reference value that the serious readers will want to file them.

Industry's Outlook: The textbooks and the transactions of the learned societies cannot possibly record all the developments that are taking place today and are often "preaching to the converted." Moreover, modern economic conditions make it increasingly difficult for ordinary men—especially the younger men from whose ranks must be drawn the executives of tomorrow — to acquire and retain all the published books and papers relating to







The Type "C" Speed Reducer has these "In-built" Factors:

Sealed Housings. Dual closures and one-way vents keep oil in, dust and moisture out. Units are splash-proof, leakproof, dust-proof.

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.

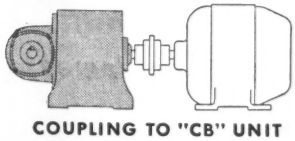
Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

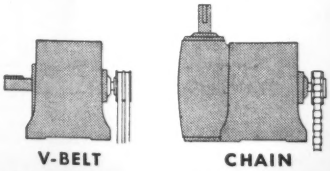
All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.

Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

A FEW TYPICAL DRIVES FOR "C" AND "CB" UNITS



COUPLING TO "CB" UNIT



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The ideal type for Turbine, Engine or Special Motor

Here is an exceptionally versatile member of the famous FALK line of reduction units. The Type "C" Straight Line Speed Reducer is an all-steel concentric shaft unit rated in accordance with AGMA standards. It is structurally similar to the universally popular FALK Motoreducer, and offers many advantages to designers and manufacturers of industrial equipment.

It can be driven by motor, turbine or engine with direct coupling connection—or through a V-belt or chain drive. It lends itself effectively to hydraulic coupling, brake-wheel or overload protective coupling, multi-speed transmission, or to variable speed drives—without modification. Units can include self-contained backstop if desired. Ratio can be modified with easily installed stock gears. With modifications, unit can be used as a speed increaser.

These all-steel Straight Line Speed Reducers are *available for prompt delivery* in standard ratios in horizontal and vertical concentric models, also in horizontal and vertical right-angle models; in single, double, triple and quadruple reduction. For full details, write for Bulletin 1104.

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If you know gearmaking, you will be the first to agree that production of high precision, heat treated, automotive type GEARS requires a major capital investment in metallurgical, processing, testing, checking, inspecting and engineering facilities.

Fairfield has these facilities, plus expert "know how" in making gears EFFICIENTLY and ECONOMICALLY.

Are you an EXPERT in making GEARS?

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Whether you are a "gear expert" or not, we believe it will pay you to check with FAIRFIELD on your current and future requirements for gears. Fairfield is one of America's largest independent producers of fine gears *made to order* for all kinds of modern machinery. *Your inquiry will receive prompt attention.*

Fine Gears Made to Order

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Fairfield MANUFACTURING COMPANY

2307 So. Concord Road
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Ask for a copy of this illustrated bulletin.

Design Abstracts

their particular fields.

Hitherto, the technical press has gone far to meet that disability, to fill gaps in the records of technical achievement, and often to promote further advances; but it can only continue to do so if accorded the necessary support. Given that support not grudgingly or of necessity but with the real confidence and even enthusiasm of those who direct both the administrative and the technical sides of industry, it can be of even greater value to both designer and producer in the future than it has been in the past.

Advertising aspects cannot be belittled since printing and other costs are at such a level today that no technical journal could be produced without the financial aid advertising pages represent except at a price few readers could afford to pay. The prime function of the technical press must be educational in the truest and widest sense of that sometimes misapplied word. If that aim is kept constantly in view by readers, contributors, and advertisers as well as by those who conduct technical journals, the other desired benefits will follow to profession and industry alike.

The utility of the technical press depends entirely on the user. Readers may be assured that in anything that will make for progress in engineering, the technical press will continue to stand as a good friend of industry.

From the Calvin W. Rice Memorial Lecture entitled "Position of the Technical Press in Relation to Industry" presented at the ASME Fall Meeting in Rochester, N. Y., October, 1953.

Increasing Reliability of Electronic Equipment

By Thomas W. Rogers, Capt.

Assistant Director of Electronics
U. S. Navy
Bureau of Ships
Washington, D. C.

THE U.S. NAVY has long realized the importance of re-

Mr. Charles T. Button, Sales Mgr.
Holtzer-Cabot Motor Division.

"Put our Motor Experience to Work for You!"

"Here at Holtzer-Cabot, we have a superb team of motor specialists who can—and do—solve practically any motor problem that is given them.

"I've been connected with the motor business for nearly 30 years, yet every now and then our design and development engineers will come up with a motor innovation, adaptation or solution that makes me blink!

"Our sales representatives, too, are something to be proud of. They're men of long experience in motor application problems, they have a thorough knowledge of the business, and give customers sound advice and help.

"If *you* have a problem in small-motor applications, take advantage of Holtzer-Cabot's organizational skill and depth of experience. The same engineering ingenuity and manufacturing excellence that have made Holtzer-Cabot the standard of high quality in motors and related electrical apparatus for 78 years are yours to command.

"Write, wire or phone. There is, of course, no obligation on your part by doing so. Your problem will get expert—and prompt—attention."

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Sales Service Representatives in Principal Cities throughout the Free World

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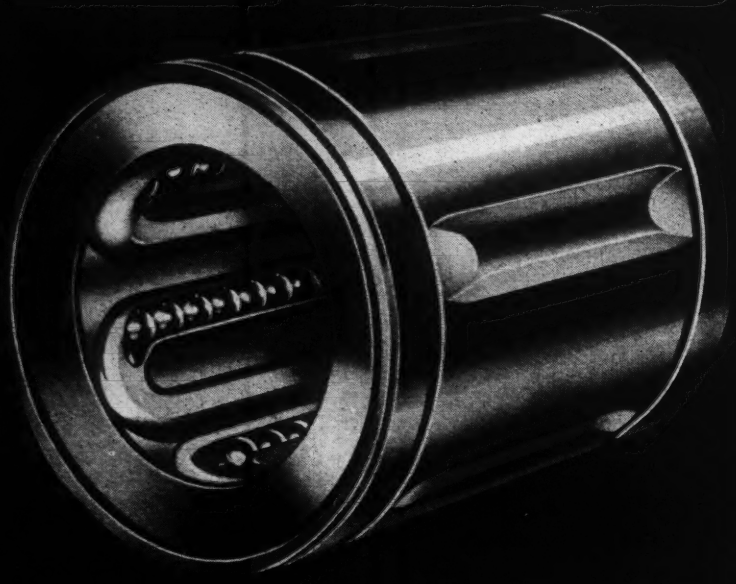

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Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for ¼", ½", ¾", 1", 1½", 2" and 2½" shaft diameters.

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Progressive Manufacturers Use Ball Bushings —A Major Improvement at a Minor Cost

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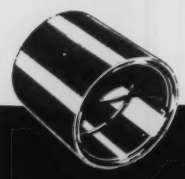

Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

liability in its electronic equipment, both from an electrical and a mechanical standpoint. In the last few years, efforts to improve electronic equipment in this respect have been greatly intensified. Of course it is recognized that reliability of actual equipment operation, simplicity of mechanical and electrical or electronic design, and ease of maintenance must all be balanced with reasonable design and development costs. This cannot be overemphasized because it is not uncommon for a piece of navy electronic equipment which sells for $10,000 to cost $500,000 to $750,000 to design and develop.

Reliability: Although it is not new, the problem of reliability is somewhat of an elusive thing. Turning back the clock 100 years, designers were striving for reliability then. For example, the old "one hoss shay" was designed so that the rails would last as long as the sills, and they would all wear out together—100 years to the day. The navy is working on the same theme.

It takes time and money to arrive at the simplest design; often a more complicated device may do a job, but a little more engineering would have made it into a simplified piece of equipment.

Many sources of information can be utilized to determine to a relative degree the reliability of electronic equipment in the field. Operational and maintenance failure reports, inspection teams, personal contacts with operating personnel, reports from equipment contract engineers, and costs of maintenance are but a few of the many ways of measuring reliability.

Equipment Unreliability: The Navy Electronics Supply Office alone issues orders totalling 39 million dollars per year for maintenance parts, tubes, and materials for electronic equipment under its jurisdiction. Although failure reports received from the fleet are only a small portion of those that should be submitted, nevertheless, the Bureau of Ships alone receives approximately 40,000 failure reports per month. Obviously cost

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All machinery made by man requires servicing at times. Every manufacturer has two responsibilities: First, to build his equipment in a way that will require the least amount of servicing. Second, to see to it that servicing, when needed, is handled with speed, efficiency and low cost.

Vickers hydraulic equipment is built to keep service requirements to an irreducible minimum. But when service is required, it is handled by Field Service Specialists working out of Vickers offices from coast to coast. These men have been carefully trained in Vickers plants and are thoroughly competent. They know how to adjust and maintain any piece of Vickers equipment . . . any combination of components. They are also qualified to instruct customers' service organizations in improving their hydraulic maintenance practices. These men devote their full time to servicing Vickers products in customers' plants. They do their job well and at minimum expense.

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

how CHACE THERMOSTATIC BIMETAL GUARDS AGAINST FIRES IN FireStaT

A Product of
The FireStaT Co.
Wheaton, Ill.

One of the simplest and most economical, completely effective automatic fire detection units is the FireStaT, actuated by two Chace Thermostatic Bimetal elements. Because of its low cost, many units can be used to protect a wide area economically, and as an open circuit is used there is no cost of operation.

A unit is located in an area to be guarded and connected in series with a power supply of 24 volts or less, and a warning device such as a light or bell. Where higher powered warning devices are indicated, or where a long line is required, the FireStaT is connected to a relay to step up the power.

The two Chace Thermostatic Bimetal elements give double protection. At an increase in ambient temperature the elements deflect toward each other. As the tip of either element touches the other, the circuit is closed. Increase in temperature brings both tips more forcibly in contact and in a sliding action, giving a positive double contact. Thus, a dependable warning signal is assured. FireStaTs come in standard models which give warnings at 140, 190, or 250 degrees F.

This illustrates but one of the many applications of Chace Thermostatic Bimetal as the actuating element for temperature responsive devices. If your product responds to, indicates or controls temperature changes, actuate it with dependable Chace Thermostatic Bimetal. Write today for our new 36-page booklet, "Successful Applications of Chace Thermostatic Bimetal", containing condensed engineering data and information.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Design Abstracts

of maintenance and failures occurring in the field indicate that the degree of reliability obtained from electronic equipment is far from satisfactory.

What are the factors which tend toward unreliability and how can these factors be combated? First and foremost probably is the complexity of equipment created by the ever increasing demands of operational requirements. This is a difficult problem and one which will be with us constantly. Nevertheless, it is an area with which we can successfully cope, and progress is being made in this area. In addition to this, poor designs, inadequate manufacturing techniques and quality controls as well as careless maintenance practices create unreliability in the field. These problems are being attacked from all directions, but in the main they add up to simplification of equipment and systems, standardization, ruggedization, intelligent testing and evaluation programs and development of reliable tubes and components with close co-ordination with industry wherever possible. Programs are being set up which include standardized reliable subassemblies which will ultimately be produced by automatic machine techniques and will, in the main, be repairable.

Equipment Specification: In the specification program, general specifications are being revised to reflect the latest thinking in reliability, simplicity and ease of maintenance. The new specifications call for the use of new, higher quality, reliable tubes. In connection with parts selection and application data, the Bureau of Ships is establishing preferred-parts lists which will include newly developed and tested component parts presently in use. These single service specifications will be co-ordinated to obtain triservice approval on parts. Establishment of preferred parts lists is a step toward reliability because parts whose capabilities are known will be used. It also establishes a measure of standardization.

Simplification: The increasing

When Choosing Clutches and Brakes for Your Equipment, Look Over These

CHECK POINTS OF FAWICK SUPERIORITY

In selecting clutches and brakes for your equipment, Fawick is your logical choice. Check these six points of Fawick superiority.

1 DRUM-TYPE AIR OPERATION

Fawick clutch and brake units provide a 360° friction surface and uniform-pressure, constant-velocity contact between the full width of the friction shoes and the drum. Greatest operating torque results from the application of operating pressure at the maximum diameter.

2 OPTIONAL CONTROL

Local or remote finger-tip control of instantaneous and smooth starting and stopping increases operating efficiency. Clutch or brake action can be sensitively regulated while units are in operation.

3 SELF-ADJUSTING

The rugged Fawick actuating element automatically compensates for wear of friction shoes. This insures complete engagement and dependable service from Fawick clutches and brakes.

4 LOW MAINTENANCE

Even friction-shoe wear reduces lost production time for clutch or brake maintenance. After long periods of satisfactory service, only the friction shoes need be replaced.

5 NO LUBRICATION

Fawick design and construction eliminate the problem of clutch or brake lubrication.

6 SPACE-SAVING

Space requirements for Fawick installations are minimized due to the small number of moving parts and elimination of mechanical linkages. All conventional mounting arrangements are made with a substantial saving of vital axial space.

A Fawick clutch or brake of the drum-type and size to meet your machine design and operating requirements is the best solution to your application problem. Check with Fawick before you buy.

FAWICK Airflex

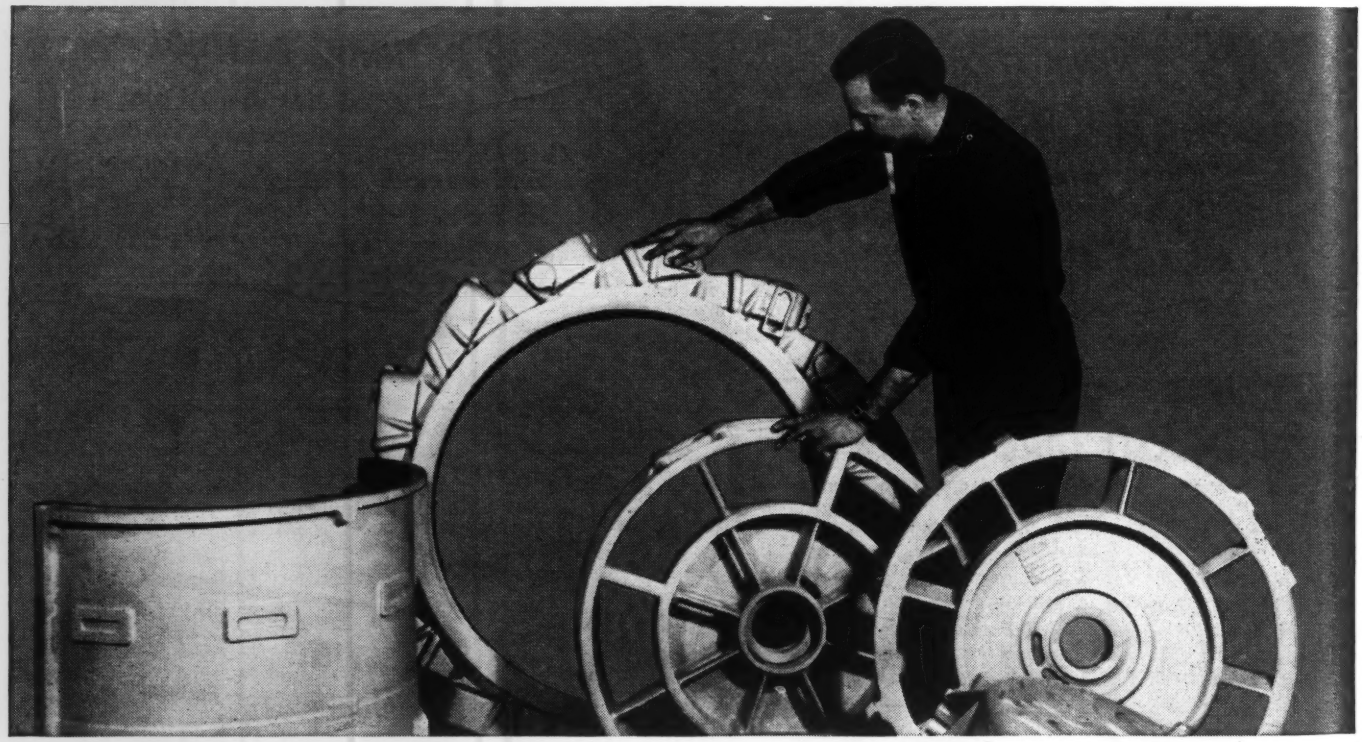
INDUSTRIAL CLUTCHES AND BRAKES

FAWICK AIRFLEX DIVISION
FEDERAL FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO

DOW

LIGHTER, MORE RIGID CASTINGS MADE WITH DOW MAGNESIUM

Production economies also offered by sand and permanent mold castings



Lighter, yet more rigid castings! That's the big advantage of magnesium in sand and permanent mold castings.

By increasing section thickness and adding stiffening ribs, greater rigidity is possible. And because of magnesium's high strength to weight ratio, total weight can be cut.

Magnesium also offers outstanding production advantages. Chief among these is magnesium's excellent machinability. There are many instances where time saved in machining has lowered the cost of the finished part beyond that of any other metal. Cutting tools last longer; replacement costs and downtime for sharpening and resetting are reduced.

Look, too, at the cost saving possible in handling. Magnesium's lightness can cut the costs of shipping, from raw casting to finished product. In-plant materials handling costs can also be reduced appreciably when lighter castings are used.

For further information on the advantages of magnesium, contact your nearest Dow sales office or write THE DOW CHEMICAL COMPANY, *Magnesium Department*, Midland, Michigan.

you can depend on DOW MAGNESIUM

DOW

versatility of operational requirements is being manifested by growing complexity of electronics equipment. This increased complexity is recognized as a major factor of reduced reliability and increased maintenance problems. Accordingly, the situation poses a design problem in that the same technical ends must be accomplished with equipment that is less complicated and less expensive without forsaking the quality and performance required by service. Simplification of circuits, equipment, and systems must be carried out as a design objective from the very first stages of equipment and systems planning, up through the design, development, and production phases.

An example of simplification occurred when the requirements of some sonar equipment were reviewed. This resulted in the deletion of an oscillator and a mixer in the transmitter unit, providing greater stability and eliminating channel crosstalk problems. On this same equipment, which originally employed a three-phase synchro-system in the plan-position-indicator unit and 22 adjustment controls, further development simplified the design to a two-phase deflection circuit. This change resulted in the removal of 14 mechanical adjustments leaving only 8.

Standardization: Benefits derived from equipment standardization are well known. The effects become apparent through better performance, ease of maintenance, simplified logistics and overall, long-range economy. As an example of equipment standardization, a series of five different World War II transmitters, each designed for a different transmitting frequency range, have been standardized by employing identical chassis, power supplies, and modulator units for each range.

Similarly, in the design of communications receivers, a basic unitization program has been followed. The basic receivers are designed to use the same power supply, audio sections, i.f. strips, chassis, and cabinet. Different ranges are accomplished by separate r.f. sections

(*Continued on Page 298*)

MARVEL *Synclinal* FILTERS

Answer Designers S. O. S.

For Dependable Protection On All Hydraulic And Other Low Pressure Oil Circulating Systems

Simple, Balanced Design . . . is the answer to the growing preference for MARVEL Synclinal FILTERS. Designers are specifying Marvel Synclinal Filters to assure minimum maintenance and maximum protection. Results show Marvel Synclinal Filters superiority in maintaining the greatest degree of cleanliness of liquids in all hydraulic and low pressure systems with minimum down-time. Furthermore, when filter servicing is necessary, Marvels can be easily disassembled, cleaned and reassembled by any workman in a matter of minutes. Line types operate in any position and may be serviced without disturbing pipe connections.

Again and again, Marvel Synclinal Filters have demonstrated they meet all requirements of the most exacting users, that today—OVER 400 ORIGINAL EQUIPMENT MANUFACTURERS MAKE MARVEL SYNCLINAL FILTERS THEIR CHOICE.

A SIZE FOR EVERY NEED

Marvel Synclinal Filters are available in sump and line types, in capacities from 5 to 100 g.p.m. Choice of monel mesh sizes from coarse 30 to very fine 200. Depend on Marvel Synclinal Filters for all your filtration requirements.

IMMEDIATE DELIVERY

Marvel not only delivers a top grade filter in both quality and performance, but delivers IMMEDIATELY—shipments are made the same day as orders are received if desired.

WATER FILTERS In response to the great demand, we have adapted both our sump and line models for use in all water filtering applications. No changes have been made in the basic synclinal design.

MARVEL
ENGINEERING COMPANY
625 W. Jackson Blvd., Chicago 6, Ill.
Phone: Franklin 2-4431

Marvel Engineering Company MD-2
625 W. Jackson Blvd., Chicago 6, Ill.

Without obligation, please send me complete data on Marvel Synclinal Filters as follows:

Catalog #106 for Oil Filters
Catalog #300 for Water Filters

Name _____
Company _____
Address _____
City _____ Zone ____ State _____

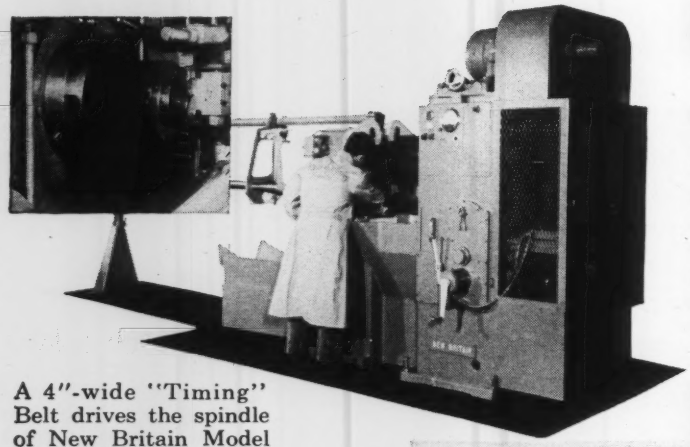
Here's How the Revolutionary

Gilmer "TIMING"®

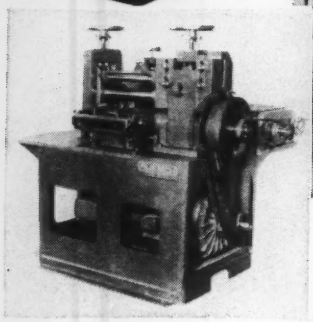
has been enthusiastically adopted by America's

MACHINE TOOL INDUSTRY

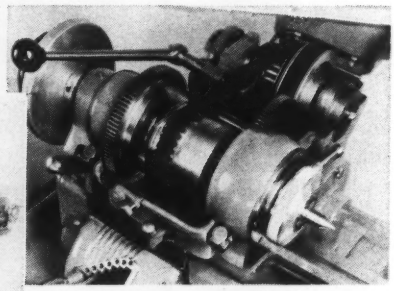
MACHINE TOOL designers have found in the Gilmer "Timing" Belt Drive a superior means of transmitting power more quietly, more efficiently, more economically, with more precise synchronization, and at constant angular velocity. On metal cutting and grinding machines the "Timing" Belt Drive has shown the way to minimize vibration and tool chatter, resulting in finer surface finish. Shown here are only a few representative machine tools now making use of Gilmer "Timing" Belts on their most vital drives.



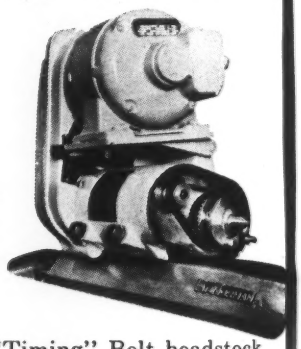
A 4"-wide "Timing" Belt drives the spindle of New Britain Model 126 Automatic Bar Machine.



Ruesch #149 Gang Slitter employs 3 *stock* "Timing" Belt Drives from 20 HP motor.

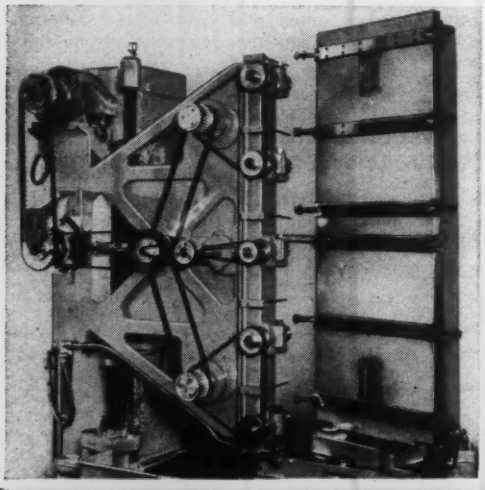


Wade Precision Lathe uses "Timing" Belt spindle drive.



"Timing" Belt headstock drive on Van Norman Radial Grinder permits finer finishes.

Eight "Timing" Belt drives provide excellent carbide tool life and finishes on Pratt & Whitney Duplicator.

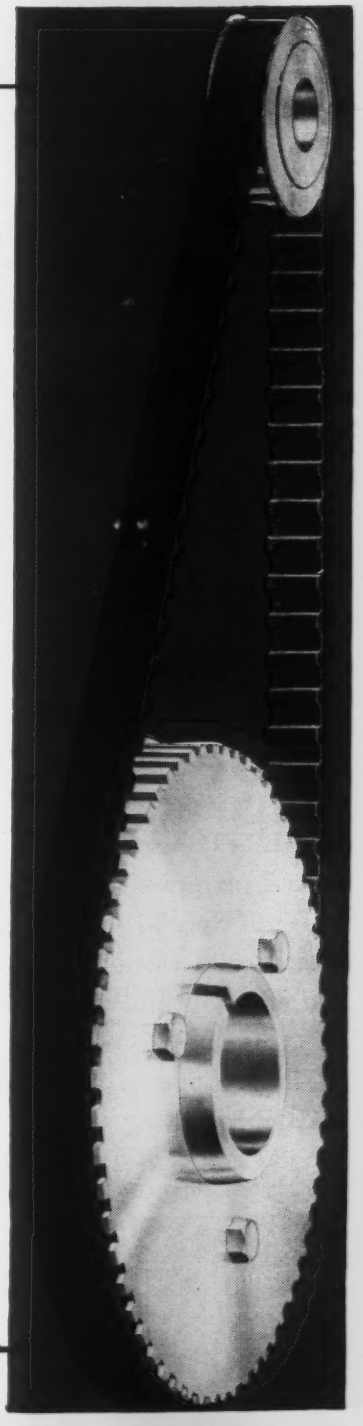


"Timing" Belts are used to drive Waterbury-Farrel Screw Head Slitting Machine.

NEW YORK BELTING & PACKING CO. • Founded 1846

NYB & P

BELT DRIVE



Industry's New Power-Transmitting Medium

Sweeps away design restrictions

In one application after another, "Timing" Belt Drives have enabled machine designers to achieve basic engineering improvements—or to design entirely new machines—that were previously either impractical or impossible! For never before has there been a *positive drive* that combined all these desirable characteristics:

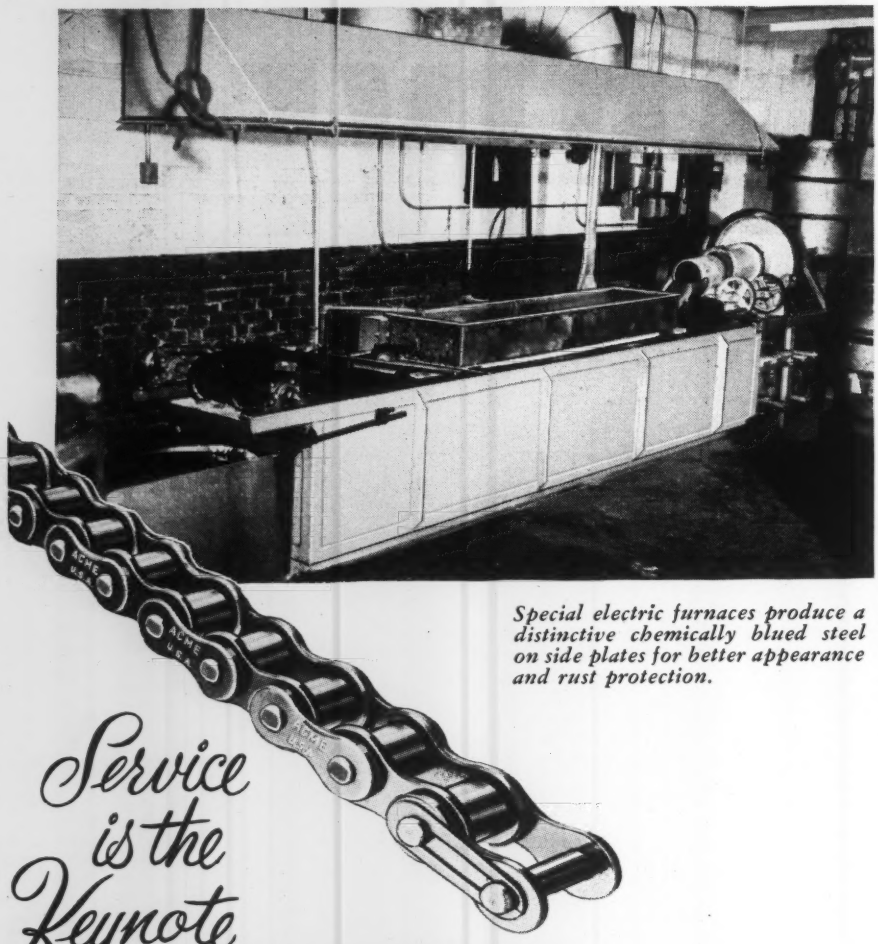
- **Requires no lubrication, no housings or lubricant guards.**
- **Maintains precise synchronization ("timing") between shafts.**
- **Provides speed ratios as high as 15 to 1 in a single step.**
- **Operates satisfactorily at speeds from inches per hour to 15,000 fpm.**
- **Permits use of very small diameter pulleys for ultra-compact drives.**
- **Has nearly 100% mechanical efficiency.**
- **Needs no initial tension. Lighter bearing loads permit lighter bearings.**
- **Does not stretch or lengthen with use; requires no take-up.**
- **Can be designed for zero backlash.**
- **Capacity ranges from 1/100 to 300 horsepower.**

These are but a few of the unique features of this amazing tooth-grip belt drive that is already in successful use on hundreds of thousands of machines. Consult your local NYB&P Distributor—or write direct for the new 76-page Gilmer "Timing" Belt Standard Drive Manual listing hundreds of drives now available promptly *from stock*. Address Gilmer "Timing" Belt Division of New York Belting and Packing Co., 1 Market Street, Passaic, N. J. or phone PRescott 7-6940.

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products

No. 3 - Precision Operations in the Manufacture of ACME Chains



Special electric furnaces produce a distinctive chemically blued steel on side plates for better appearance and rust protection.

Service is the Keynote OF **ACME'S** SUCCESS

By SERVICE we mean shipments made the day order is received on practically all standard makes of ACME Chains.

On "Special Chain" orders, we aim to make deliveries one or two weeks sooner than you would normally expect. Large stocks and flexible manufacturing facilities make this possible.

Telephone in your next order and get acquainted with ACME lightning service.

Write Dept. 6E for new illustrated 76 page catalog on use and application of roller chains and sprockets.

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

Design Abstracts

(*Continued from Page* 295)

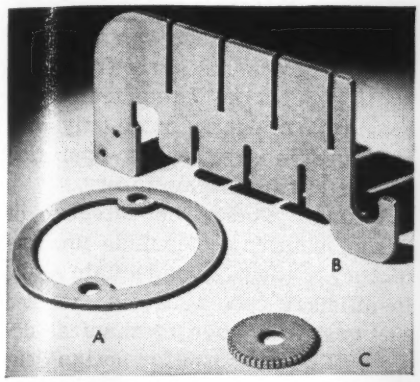
with remote control or automatic channel selection features accessory to the basic design. The new family of standard receivers will eventually replace many different models now installed. Larger receivers are also being designed to utilize units common to several types of equipment.

Other efforts for equipment standardization include standardization of racks, panels, chassis mountings, and accessory units such as remote control units, antenna stabilization units, power supplies, voltage regulators, etc.

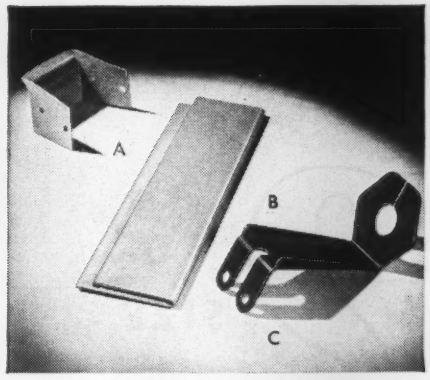
Component Failure Causes: Under a Bell Telephone Laboratories contract, part failures occurring on a selected eleven ships were kept under close surveillance. Circumstances surrounding these failures were carefully annotated and forwarded with the failed part for careful examination to more fully determine the cause of failures. Over a period of approximately one and one-half years, 1763 failed components were examined. Analysis of compiled information showed that 31 per cent of the failures were caused by operational conditions, 28 per cent were caused by manufacturing defects, 26 per cent resulted from design deficiencies, and for 15 per cent there was insufficient evidence to form a definite opinion.

Failures assigned to operational conditions include failures resulting from circuit and equipment deficiencies, handling, faulty installation, and environment. Remedies in this area will be largely in the form of equipment specification changes, adequate circuit protection, better electron tubes (higher quality, reliable tubes), moisture sealing, improved equipment cooling and, possibly, instructions for greater care in handling and installing of parts.

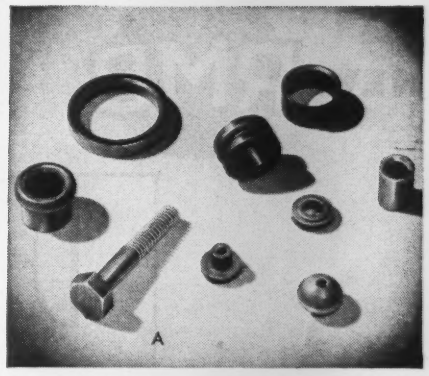
Manufacturing defects, which accounted for 28 per cent of the failures, include poorly soldered joints and seals, defective or omitted insulation, contamination leading to corrosion, wrinkled foils, etc. Better inspection and control of manufacturing process methods would have prevented most of these



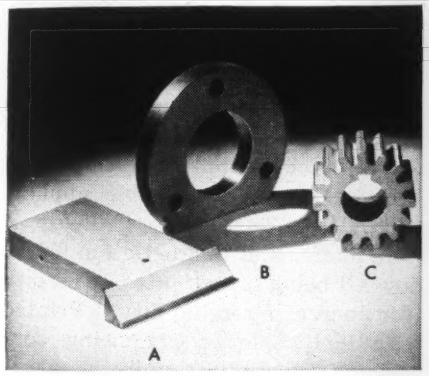
A. Sheet stock, shear strips, punch. B. Sheet stock, shear, punch blank, gang saw notches. C. Sheet stock, shear strips, punch blank, mill notches.



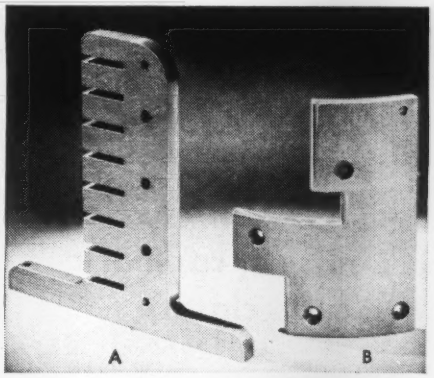
A. Sheet stock, shear strips, punch, form. B. Sheet stock, shear to size, drill, form. C. Sheet stock, shear strips, punch pieces, form in mold twice, rubber stamp twice.



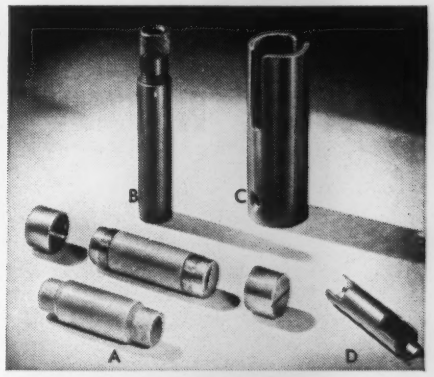
A. Rod (hexagonal), smooth saw, automatic screw machine, turn shoulder thread, champfer and cut off. Remainder are automatic screw machine parts made from Diamond Fibre by C-D-F.



A. Sheet stock, sand, smooth saw to size, smooth saw bevel, smooth saw corner cut out, drill. B. Sheet stock, band saw, turn OD, bore ID, smooth saw side, drill five blind holes with jig. C. Sheet stock, sand, band saw, rough bore ID, hob teeth, finish bore ID, machine keyway.



A. Sheet stock, sand, smooth saw, drill, smooth saw to shape, radius three corners, gang saw nothches. B. Sheet stock, band saw rough blanks, form, smooth saw width, length and shape, radius edges, drill with jig, countersink.



A. Tube, automatic screw machine, turn shoulders, champfer and thread end, thread other. B. Tube (long pieces), smooth saw, tap threads, screw machine, (small pieces) auto. screw machine, thread, knurl, champfer, cut off. C. Tube, smooth saw to length, punch twice, countersink. D. Tube, automatic screw machine, champfer, cut off, punch.

C-D-F fabricates and forms DIAMOND VULCANIZED FIBRE

FAST . . . AT LOW COST . . . DEPENDABLY

Vulcanized Fibre is a wonderful material if you know where to use it and how to buy it. We suggest on many jobs that it's best to do the fabrication and forming in C-D-F's shops. Why? Because C-D-F knows how. Since 1895 the company has put fibre to work in everything from buggy axle bushings to metal clad radio parts. The handling of thousands of set-ups for high speed, low cost production runs gives C-D-F an "experience bank" to draw from. Shop supervisors have a wealth of short cuts, little tricks that result in lower prices for you. They know the material and its peculiarities.

TOUGH, RESILIENT, STRONG

How long has it been since you examined the unique properties and wide range of C-D-F fibre grades? Vulcanized Fibre is arc resistant, mechanically strong, non-corroding, half the weight of aluminum. Repeated moistening and drying in forming insignificantly alters the nature, structure or quality of the fibre.

Since C-D-F has their own paper mill, uniform, quality control is made possible. Special grades are more easily developed. A good example is C-D-F Abrasive Fibre, a medium density fibre with excellent resin and grit adhesion, now widely used for abrasive discs.

A BIG, RELIABLE SOURCE

C-D-F does business with the largest tonnage users of sheet, rod and tube fibre in the world. This means good deliveries, good prices, reliable products for every new customer. You deal with a materials engineer, a C-D-F man who knows how to give you the most value in Diamond Vulcanized Fibre. If you want to improve design, simplify purchasing, speed production, use Diamond Fibre and the facilities of C-D-F. Write for catalog, free test samples, or send us your print for quotation.

CDF *Continental-Diamond Fibre*

CONTINENTAL-DIAMOND FIBRE COMPANY

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NEW RMB

R2 SIZE*

MINIATURE BALL BEARINGS ARE NOW Available

Including RMB's exclusive Filmoseal capillary type closure

Ten Different Types

with or without seals for a wide range of speeds

Choose the type bearing best suited for your application.

Made to ABEC 1-3 and 5 tolerances

One of the new RMB R-2 size bearings. RMB Type RF 864 S-5-14, ABEC-5 tolerance, 1 piece snap-type ball retainer. For low torque, medium speed applications. Also available with 2-piece ribbon-type ball retainer for higher speeds.

Bring Your Miniature Bearing Problems to RMB

RMB R-2 size bearings are just a part of our complete line of over 250 miniature and instrument bearings which are available for prompt shipments, with experimental quantities available immediately from stock.

Write for your copy of Data Sheet R-21, which gives full details and specifications on R-2 size bearings; or our General Catalog 12 which tells the story on the rest of our line, as does our catalog in Sweets' Files.

* OD—0.3750", Bore—0.1250", and Width—0.1562".

RMB LANDIS & GYR, INCORPORATED

45 West 45th Street, New York 36, N. Y.

Design Abstracts

faulty components parts from ever getting into the equipment. The remedy here can be made only with the assistance and full co-operation of the parts manufacturers.

Failures under the category of design deficiencies include unsatisfactory materials, inadequate seals, insufficient strength in molded sections, and poor mechanical design. The remedies for design deficiency failure will include basic changes to parts specifications and direct contact with parts manufacturers to remedy defective design areas.

Development Trends: Newly developed materials and components as well as new techniques in circuitry and fabrication are being carefully studied for possible application. Use of transistors, dielectric amplifiers, and magnetic amplifiers are all being investigated as factors for increasing reliability. Printed circuit techniques are being considered for application in the mechanized, automatic production of subassemblies. In addition, development effort is being continued in the field of automatic production of tubes. Progress in this field is being watched with extreme interest because mechanized assembly of electron tubes will allow a high degree of quality control to be combined with mass production.

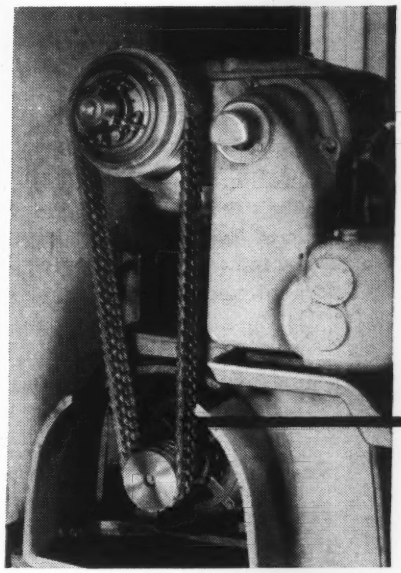
From a talk entitled "Reliability of Electronic Components" presented at a section meeting of the Institute of Radio Engineers, Cleveland, O., November 1953.

Designing Safety into Machines

By Walter E. Montgomery

Safety Director
Kenneth D. S. Roberts Ltd.
Montreal, Canada

THE ultimate design objective in safeguarding machine parts is to insure absolute immunity of operating personnel from injury. The laws of many states require that every dangerous part of any machine shall be securely guarded except where there is protection by position. Various state labor



Performance Proves 20% to 90%

LESS VIBRATION

with Veelos—the Balanced V-belt

Engineers have long known that there are four principal causes of machine vibration: 1. bearings; 2. motor; 3. clutch; 4. sheaves. Often overlooked is a fifth cause: v-belts. And, in many instances, *v-belts alone* are the major cause of vibration.

There's a logical reason for this.

Regular v-belts have spots of varying density due to their construction. Normally, these spots are not apparent, yet they throw the belt out of balance when the drive is operating. As a result, vibration is created that can damage bearings, shafts and, most important, the finished work.

This is not true of Veelos v-belts.

Veelos is absolutely uniform throughout its entire length. Every link and every stud is identical. The smooth, machine-cut sides and the laminated construction assure smooth, vibrationless power delivery. Veelos is perfectly balanced.

In case after case, installation of Veelos v-belts has reduced machine vibration 20% to 90%.

Proof that Veelos will reduce vibration can easily be demonstrated with an electronic vibration analyser. This analyser measures amplitude of vibration to as low as 2-millionths of an inch.

Fifteen minutes of your time is all that is required to show you with the electronic analyser that Veelos creates less machine vibration. Drop us a line or clip the coupon for a demonstration.

VEELOS
THE LINK
V-BELT

Manheim Manufacturing & Belting Company
606 Manbel St., Manheim, Pa.

Yes, I would like a demonstration. **Have your representative call me for a convenient time.**

Name.....

Company.....

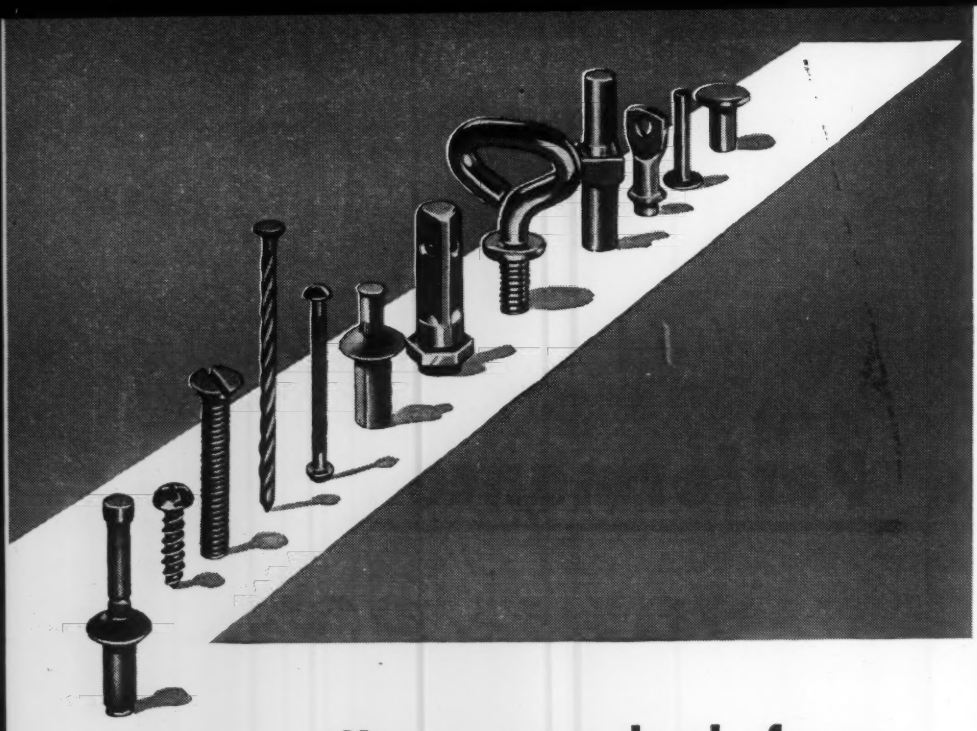
Address.....

.....

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Veelos is known as Veelink outside the United States.

2CV



How to stay ahead of your competition with Townsend special fasteners and parts

In today's highly competitive markets many design engineers and production managers find they improve products, reduce material costs and assembly time with Townsend's method of cold-forming fasteners and small parts. It enables them to put greater value into their products and at the same time hold unit costs down.

The Townsend method often replaces costly, material-wasting methods with savings that range from $.70 to $80.00 per thousand. Annual savings are often substantial—$15,816 on an automobile door lock part—$12,000 on a washing machine fastener—$11,190 on two parts for home laundry equipment—$15,630 on two refrigerator fasteners—$5,130 on an electrical connection.

Townsend engineers specialize in the assembly and fastening of all types of materials for all industry. They draw upon more than 10,000 standard and special items developed in 138 years of cold-forming experience and rely upon Townsend's capacity to produce 60-million pieces daily to give you the best in fastening methods. To learn how to improve fastening efficiency, ask to have an engineer call.

Townsend

COMPANY • ESTABLISHED 1816

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THE FASTENING AUTHORITY—Experience: *over 138 years*—**Capacity:** *sixty-million parts daily*–**Products:** *over ten-thousand types of solid rivets–cold-headed parts–Cherry Blind Rivets–Twinfast Screws–self-tapping screws–tubular rivets–locknuts–special nails–formed wire parts.*

Plants: *New Brighton, Pa.—Chicago, Ill.—Plymouth, Mich.—Santa Ana, Calif.*

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

laws have recognized a basic tenet that dangerous parts must be assumed to be injury producing parts, otherwise guarding would be unnecessary.

Of course, complete immunity from accidents will never be achieved by safe guarding alone, since an accident on machinery is caused by the combination of two actions: that of the dangerous parts, plus that of the person injured.

Danger Areas: In the design of machinery and machine guarding there are many parts and combinations of parts that are intrinsically dangerous that must be given careful consideration. Major danger areas include the following:

1. Revolving shafts, spindles, mandrels and bars.
2. Inrunning areas between pairs of revolving parts; such as, gear wheels, friction wheels, and rolls.
3. Inrunning areas of the belt and pulley type including plain, flanged or grooved belts and pulleys; chain and sprocket gears; conveyor belts and pulleys; and metal coilets.
4. Projections on revolving bars; such as, keyheads, set screws, cotter pins and coupling bolts.
5. Discontinuous rotating parts exemplified by open arm pulleys, fan blades and spur wheels.
6. Revolving beaters, spiked cylinders and drums.
7. Revolving arms in casings.
8. Revolving worms and spirals in casings.
9. Revolving high speed cages in casings.
10. Abrasive wheels.
11. Revolving cutting tools.
12. Reciprocating tools and dies including power and hand presses.
13. Reciprocating knives and saws.
14. Closing areas between platen motions; such as in platen printing machines and power presses.
15. Projecting belt fasteners and fast running belts.
16. Areas between connecting rods or links and rotating wheels cranks or disks.
17. Pawl and notched wheel de-

vices for intermittent feed motions.

18. Areas between reciprocating and fixed parts, other than tools and dies; such as, reversing stops and sliding tables and fixtures.

19. Areas between revolving control handles and fixed parts.

20. Moving balance weights and dead weights.

21. Areas between revolving wheels or cylinders in pans or on tables.

22. Cutting edges of endless bank cutting machines.

23. Areas between gears and rack strips.

24. Revolving drums and cylinders—uncased.

25. Areas between fixed parts and unidirectional moving parts.

In the assessment of the degree of danger likely to be encountered with any group of dangerous parts on a machine it is advisable, for absolute safety, to disregard associated functions such as rate of revolution, velocity of sliding parts, and frequency of approach to parts. Experience has shown that, given intrinsic danger, an accident will inevitably occur by the law of chance should the required combination be repeated a sufficient number of times.

Positional Safety: It should be noted that danger arises only in the event of a human factor being introduced. Contact with the dangerous part may be anticipated during the time when the parts are in motion. Accordingly, there is a method of removing one factor in the accident equation. Dangerous parts should be put out of reach, i.e., to presuppose that safety will be obtained by position, which is legally allowed.

Unfortunately, experience has demonstrated that access to dangerous parts is often made by careless persons, often with some considerable difficulty, thus destroying the value of positional safety. For this reason the adoption of safety by position cannot be accepted as a means for securing absolute safety.

In determining the degree of

(*Continued on Page* 306)

Here's free information to help you reduce material and assembly costs

If you assemble metal, wood, plastics, fabrics or glass, here is a wealth of free information which shows how to increase efficiency and improve products with Townsend fasteners. These bulletins describe a few of the 10,000 special and standard items now being used by all industry to reduce material and assembly costs.

Manufacturers of appliances, radio and TV sets, automobiles, aircraft, electrical equipment, farm implements, railroad rolling stock—even toys, rely upon Townsend as "The Fastening Authority" to help them fasten materials together quickly—economically—permanently. The bulletins listed below are yours for the asking.

- **Special Cold Formed Fasteners and Small Parts** explains the economy of cold-forming small parts and how to enjoy the advantages of Townsend's design service. Bulletin TL-89
- **Townsend Tapping Screws** describes seven types of tapping screws used for economical, quick, secure fastening of sheet metal, casting, forgings, plastics, plywood and composition materials. Bulletin TL-88
- **Townsend Locknuts** gives data on positive resistance to vibration and shock with Tufflok and Nylok locknuts which provide tight grip through use of special locking inserts. Bulletin TL-63
- **Cherry Blind Rivets** shows how this ingenious rivet is used by one man, from one side of the work to rivet "blind" in double-surfaced structures, box sections, tubes and ducts. Bulletin TL-76
- **TWINfast Wood Screws** explains how the two threads and double thread pitch cut driving time, increase holding power in wood-to-wood, wood-to-plastics and metal-to-wood applications. Bulletin TL-67
- **Place Bolts** describes this slotted-type, one-piece, all-metal, reusable locking bolt and how it offers cost savings in vibration fastening. Bulletin TL-73.

Townsend
COMPANY • ESTABLISHED 1816
NEW BRIGHTON, PENNSYLVANIA
Sales Offices in Principal Cities
Cherry Rivet Division • Santa Ana, California

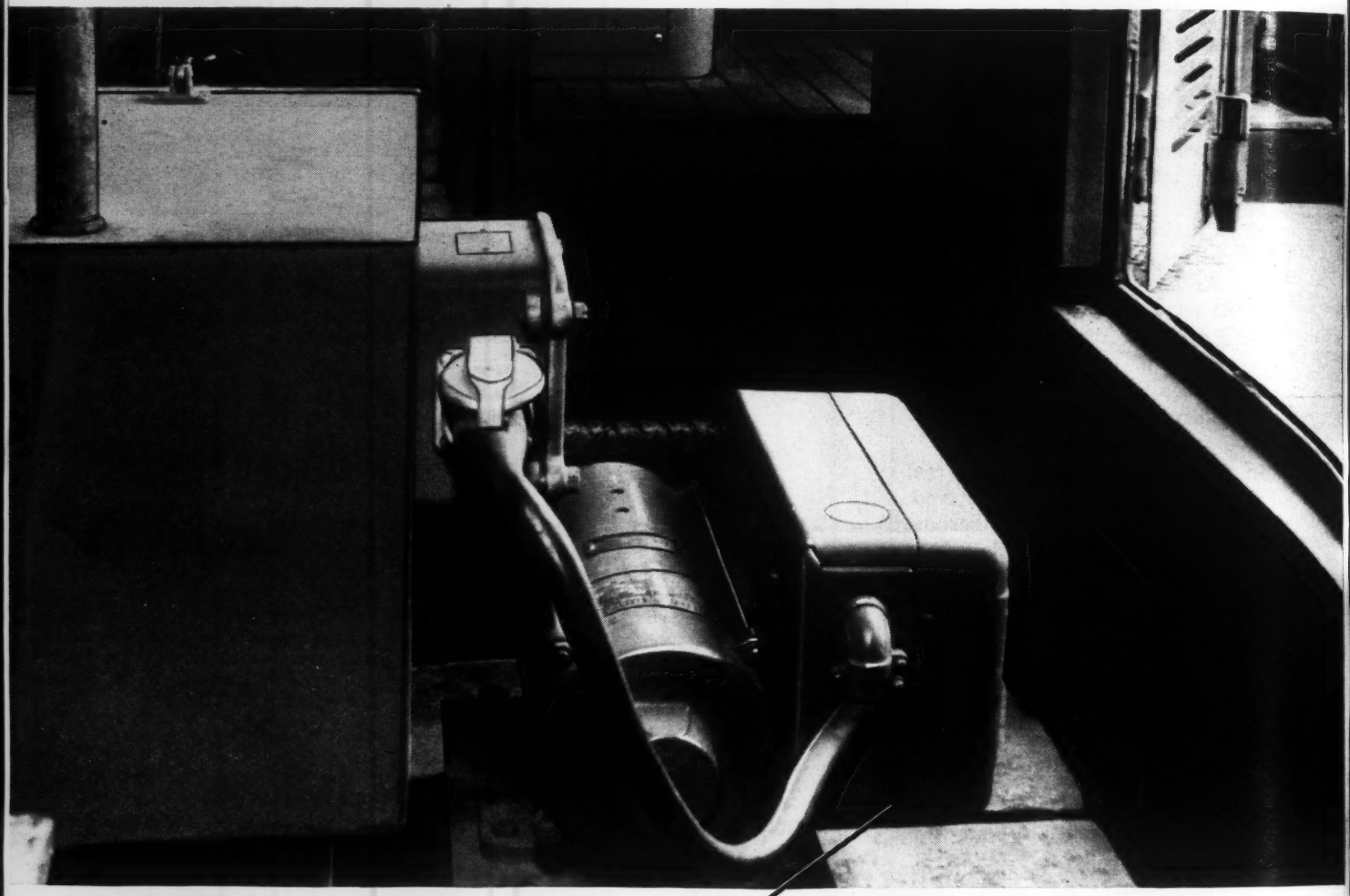
Use coupon below or write
TOWNSEND COMPANY • SALES DEPARTMENT • NEW BRIGHTON, PA.

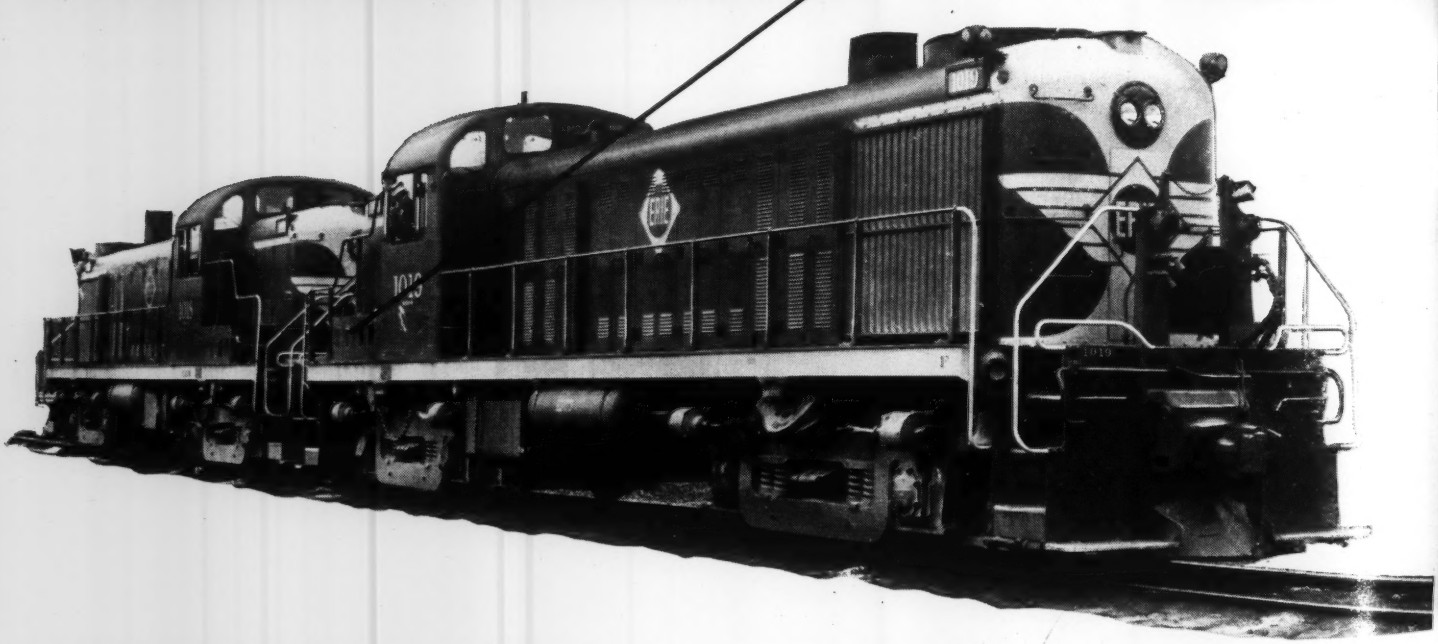
Please send to me without obligation bulletins circled below:
TL-89 TL-88 TL-63
TL-76 TL-67 TL-73

Name _____ Title _____
Company _____
Street _____
City _____ Zone _____ State _____

The Erie Railroad story shows why it pays to . . .

Get motor application

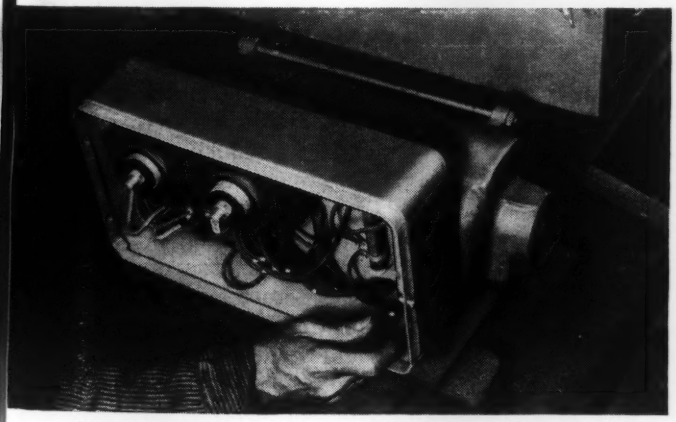




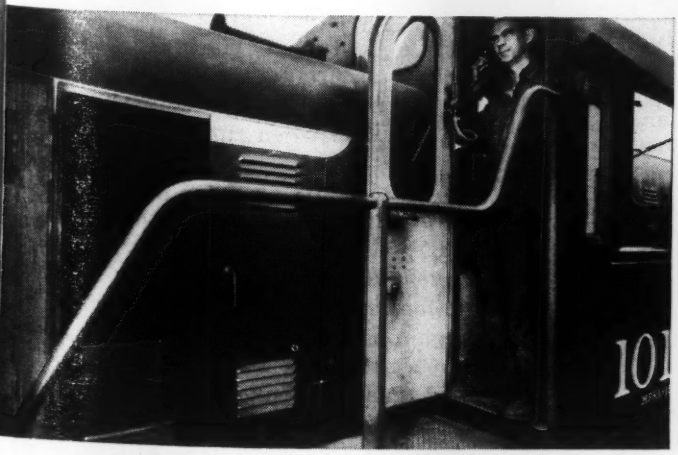
THE ERIE RAILROAD REQUIRED motor alternators to provide 115-volt, 60-cycle power for communication equipment between diesel-electric engines, cabooses, and control stations. The railroad had been using a 64-volt battery system. Illustrations (above) show the G-E designed motor alternator—chosen after competitive tests—and location in the engine. At right, is a brief story of how G-E engineers met the rigid specifications and solved the Erie Railroad's particular problem.

help from G-E Engineers

PROBLEM WAS PRESENTED to G-E sales engineer. Erie Railroad required maintenance-free operation for 3 month periods and a design that would make all servicing feasible except rewinding.



G-E ENGINEERS at the Specialty Component Motor Department in Fort Wayne, Indiana, designed a special open construction type of motor alternator to meet the railroad's precise specifications.



RUGGED TESTS were given this G-E motor alternator on a switcher in railroad's Marion, Ohio, yard. The design struck a happy medium as to design and service, now used on 75 passenger and yard diesels.

PROBLEMS of motor design and motor application are being solved daily at General Electric's Specialty Component Motor Department in Fort Wayne, Indiana. The accumulated engineering experience—unmatched anywhere—starts working for you when you bring your tough motor application problems to General Electric.

THE ERIE RAILROAD had the problem of providing a dependable power supply for their communications equipment mounted on diesel-electric passenger locomotives, switchers and cabooses. They established their needs as a motor-alternator set supplying 115-volt, 60-cycle current. Close voltage control was necessary to insure satisfactory radio tube operation.

WITH THESE REQUIREMENTS in mind, General Electric designed a 2-unit 2-bearing motor alternator which proved the merit and effectiveness of G-E application help in rugged competitive tests.

WHEN YOU HAVE a tough motor application problem, take it to General Electric. Take advantage of G-E engineering skill and talent backed by years of experience. Contact your nearby General Electric Apparatus Sales Office. General Electric Co., Schenectady 5, N. Y. 704-21

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APPLICATION HELP provided by G-E engineers in solving the Erie Railroad's problem typifies the many cases where design engineers have found it pays to take motor application problems to G.E.

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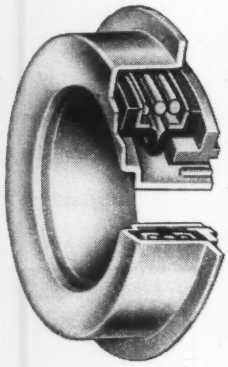
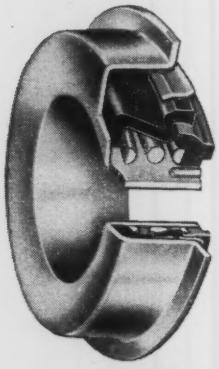


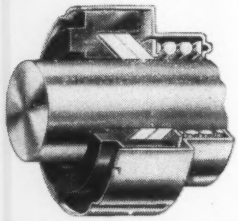
TYPE 6-A

Pressed-in packaged unit recommended for small shafts on hot or cold water, oil, gasoline or soapy liquids . . . pressures to 75 psi . . . temperatures from —65° F. to +220° F. Available in stainless steel or bronze.



TYPE 11-A

Pressed-in packaged unit with spring inside synthetic rubber bellows to protect against corrosion. For hot or cold water, oil, gasoline or soapy liquids . . . pressures to 35 psi . . . temperatures from —65° F. to +212° F.



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JOHN CRANE **CRANE PACKING COMPANY**

Design Abstracts

(*Continued from Page 303*)

danger associated with any dangerous parts of machinery, no reliance should be placed upon the co-operation of any person employed in avoiding an accident. The best assumption is that however careful a person may be, there is no guarantee that he will not meet with an accident.

It is well known that many operators look upon guards with disfavor for various reasons, but if guards are suitable for the purpose and correctly designed and fitted in relation to the parts, this animosity should not arise.

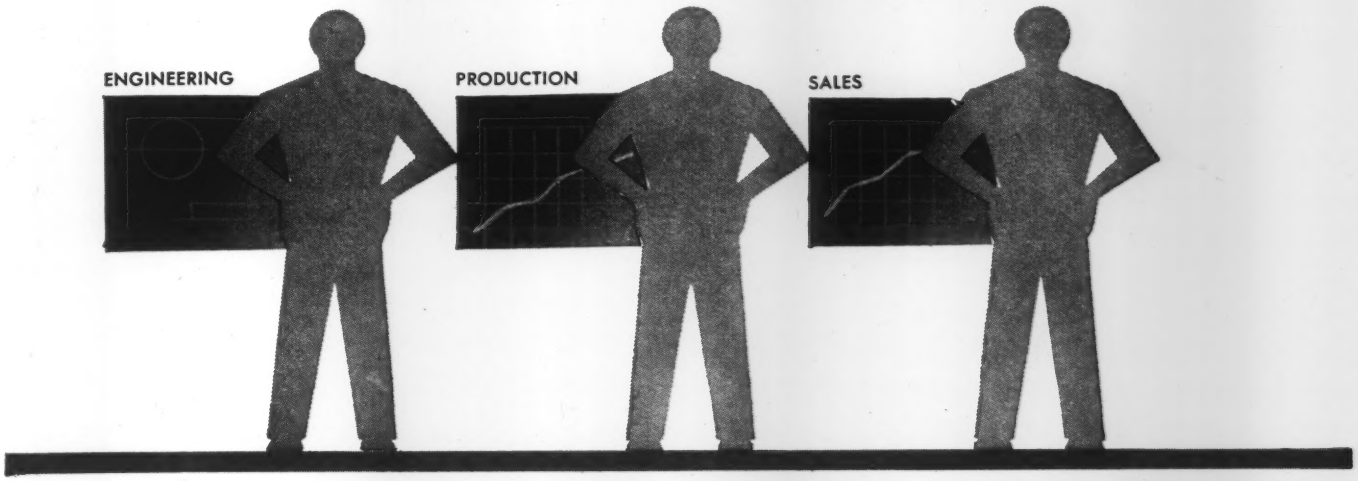
Designing Out Danger: The intrinsic danger in the 25 listed previously groups of dangerous machinery parts must be removed either at the design stage by safer construction or before use by secure guarding.

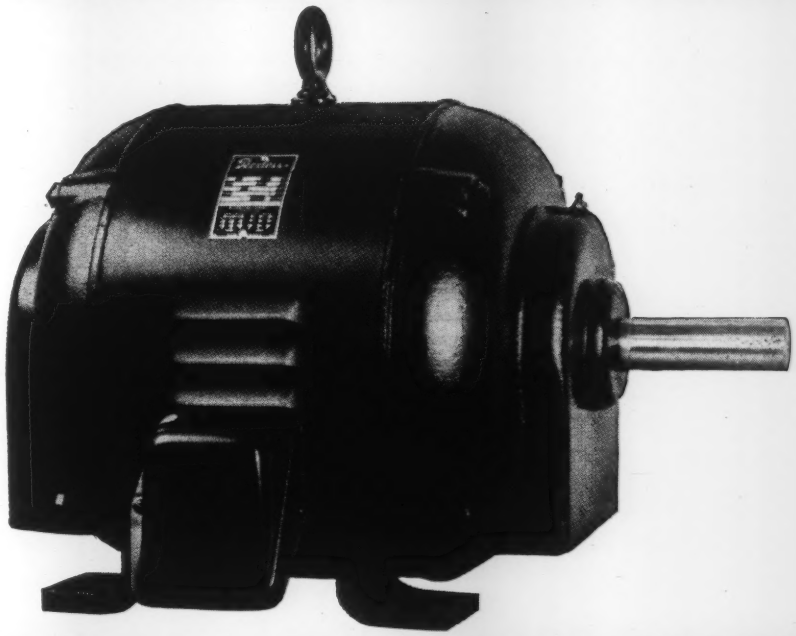
Notable examples are found in all-enclosed gear boxes of numerous machines which have ousted the older train of exposed gears. Modern machine tools show practically no revolving parts except arbor spindles, chucks, and so forth. Dangerous parts should be securely guarded on the assumption that absolute safety is the criterion by which guarding action is to be determined.

In the design of guards for certain parts of machinery, such as gears, attention must be given to the provision of protection in the event of machines being reversed in motion. This reversal might have the effect of transforming innocuous parts into definitely dangerous ones and it has been legally held that machine parts must be securely guarded not only for the normal direction of working, but also when run in reverse.

Fixed Guards: A fixed guard is one which entirely encloses dangerous parts of machinery to prevent all contacts from any direction and by any person with dangerous parts. Furthermore, the legal implication is that a fixed guard should preferentially be used instead of any other type. There are provisions in some labor codes that specific permission is

Men who value motor performance





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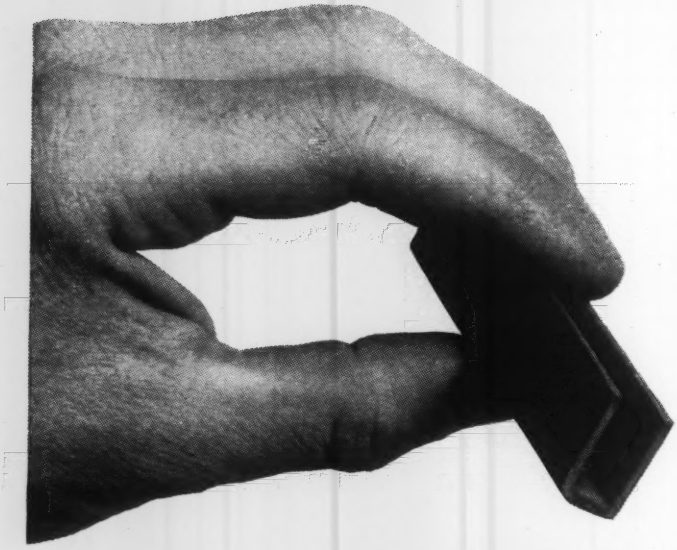

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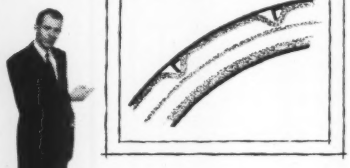

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are often used for oil or grease retention where the felt is compressed or confined in an assembly. Where operating conditions are not too severe, these grades are also used to make dust shields.

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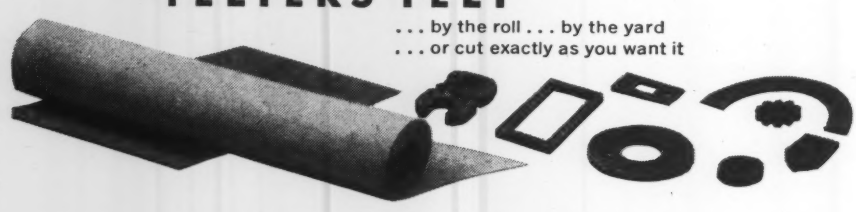


Design Abstracts

necessary for any deviation of application, and proof must be provided that safety of a dangerous part cannot be secured by a fixed guard. Every effort should be made to render the use of a fixed guard possible, and it should get first preference in design. If some redesign or rearrangement of machine parts would enable such a guard to be used then necessary arrangements should be provided or redesign effected.

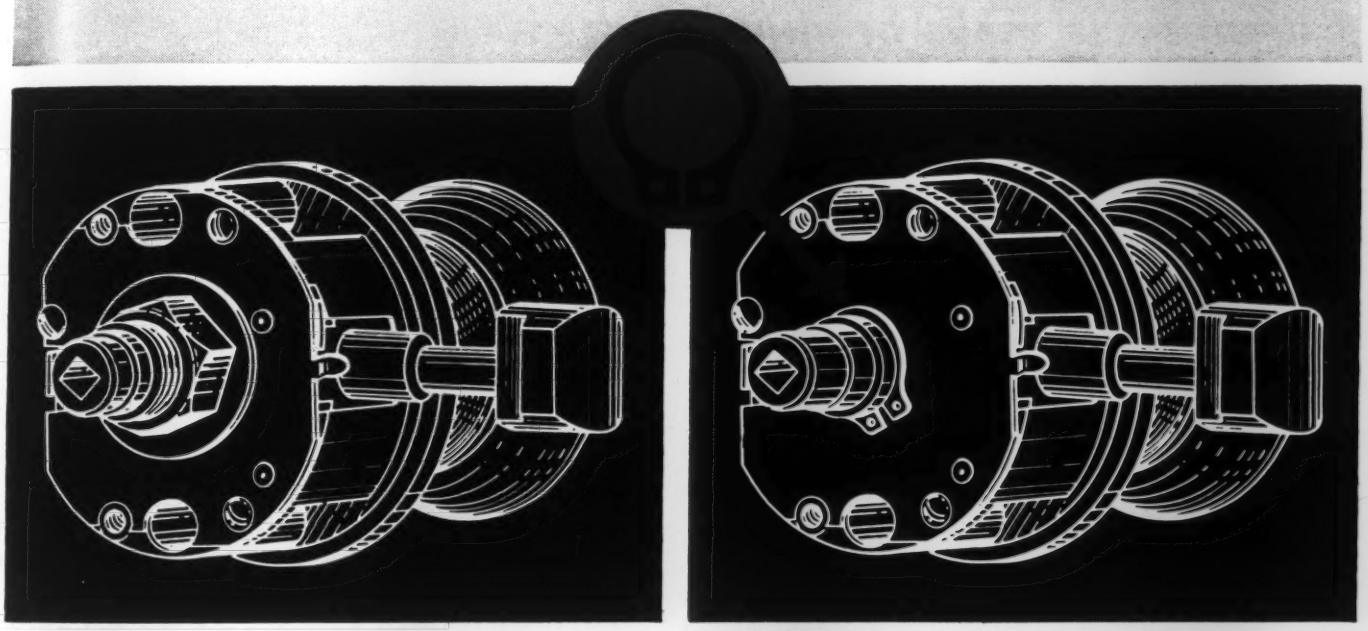
Automatic Guards: An automatic guard is one in which a certain member or combination of members is worked automatically by the machine. When dangerous parts are set in motion the guard immediately removes the operator from danger.

It is essential that this type of guard be actuated by a moving portion of the machine itself, preferably at a greater rate and with a lead in advance of the travel of dangerous parts. Theoretically, a guard should be able to fulfill its function without difficulty on any machine; but in practice the imposition of severe acceleration stresses on the guard linkwork leads to excessive wear and may destroy required critical adjustments. Accordingly, the automatic guard should be used only on slow running machines.

Interlock Guards: An interlock guard is a movable guard which by itself or in conjunction with fixed guards entirely encloses and prevents all contact with dangerous parts in motion. It must be so designed and fitted—with modifications to the machine control and other parts where necessary—that the dangerous parts cannot be set in motion through any cause whatever when the guard is open. Furthermore, when the guard is in the safe or enclosing position, it must not be capable of being opened until the equipment has been stopped. Conversely, if opened during an operation, it shall cause operation to automatically lock out before personal contact can be made.

Interlocking means that the guard is so connected or arranged

Waldes Truarc Ring Replaces Nut and Washer ...Cuts Costs $5.28 Per M...Speeds Assembly by 50%



OLD WAY. Main shaft required costly threading. Assembly was slowed by the double application of washer and nut and time-consuming tightening operation.

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Cost of Nut	$10.00	*per thousand*
Cost of Washer	3.80	" "
Labor for Threading	2.00	" "
Assembly	3.00	" "
TOTAL	$18.80	

TRUARC WAY

Cost of Truarc Ring and Grooving Operation	$11.52	*per thousand*
Assembly	2.00	" "
TOTAL	$13.52	

J. Chesler and Sons, Inc., Brooklyn, N.Y., manufacturers of the pre-assembled "Reddi-Mount" cylindrical lockset, uses a single Waldes Truarc Retaining Ring instead of an old fashioned nut and washer to secure the entire assembly of their lock. This new, improved fastening method enables Chesler to eliminate costly threading . . . save money on material . . . speed assembly time by 50% and produce an improved, more durable product.

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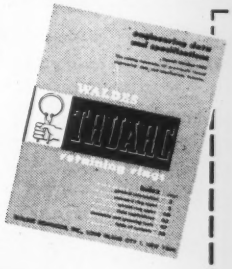

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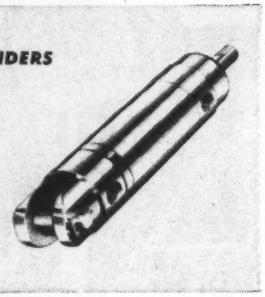

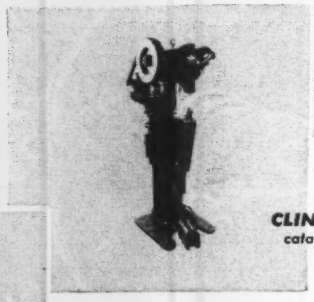

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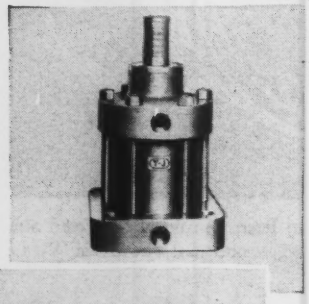

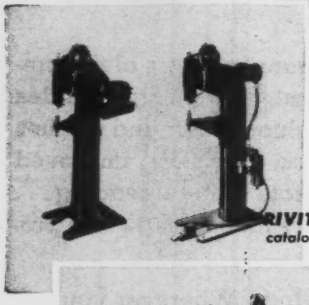

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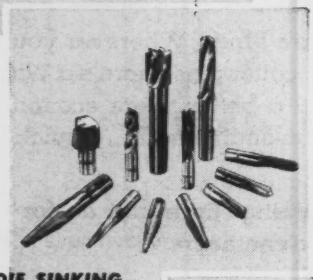

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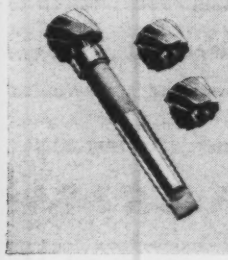

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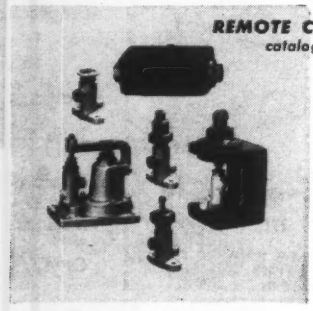

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Design Abstracts

with the operating switch that (a) dangerous parts cannot be started until the guard is in place, and (b) the guard cannot be made inoperative until the machine has stopped and the danger eliminated

Trip Guards: A trip guard is a device that stops a machine before near approach can be made to the dangerous parts. It consists of a mechanism that cuts off driving power and simultaneously applies a brake. The tripping mechanism must be designed to operate immediately when the operator creates a personally hazardous exposure. This type of a guard is commonly employed on rubber mills, ingathering rolls, laundry calenders, paper machinery, etc.

Positional Safety Guards: Consisting of fixed members, these guards are placed at such a position that access to dangerous moving parts is not possible. This is the last line of defense in the safety problem and should be used only when no other type of a guard can be adopted.

Starting and Stopping Controls: The chance of an unsafe act being performed at certain machines depends upon and varies with the method of control adopted for starting and stopping the motion of dangerous parts. The greatest risk of an accident exists in operations which necessitate constant and close co-ordination between the brain, hands, and feet, such as in operating a power press. Such equipment is subject to mechanical maladjustments and wear and tear that will eventually cause a press to be a repeater. Careful maintenance reduces this risk, but unseen faults may develop in such a way that they are not disclosed by periodic examinations.

Logically, for absolute safety, it is necessary for the operator to withdraw both hands before the press can be put in motion. This means that both hands should be used to operate the controls. These controls should be arranged to operate independently of each other,

On 15 years experience—

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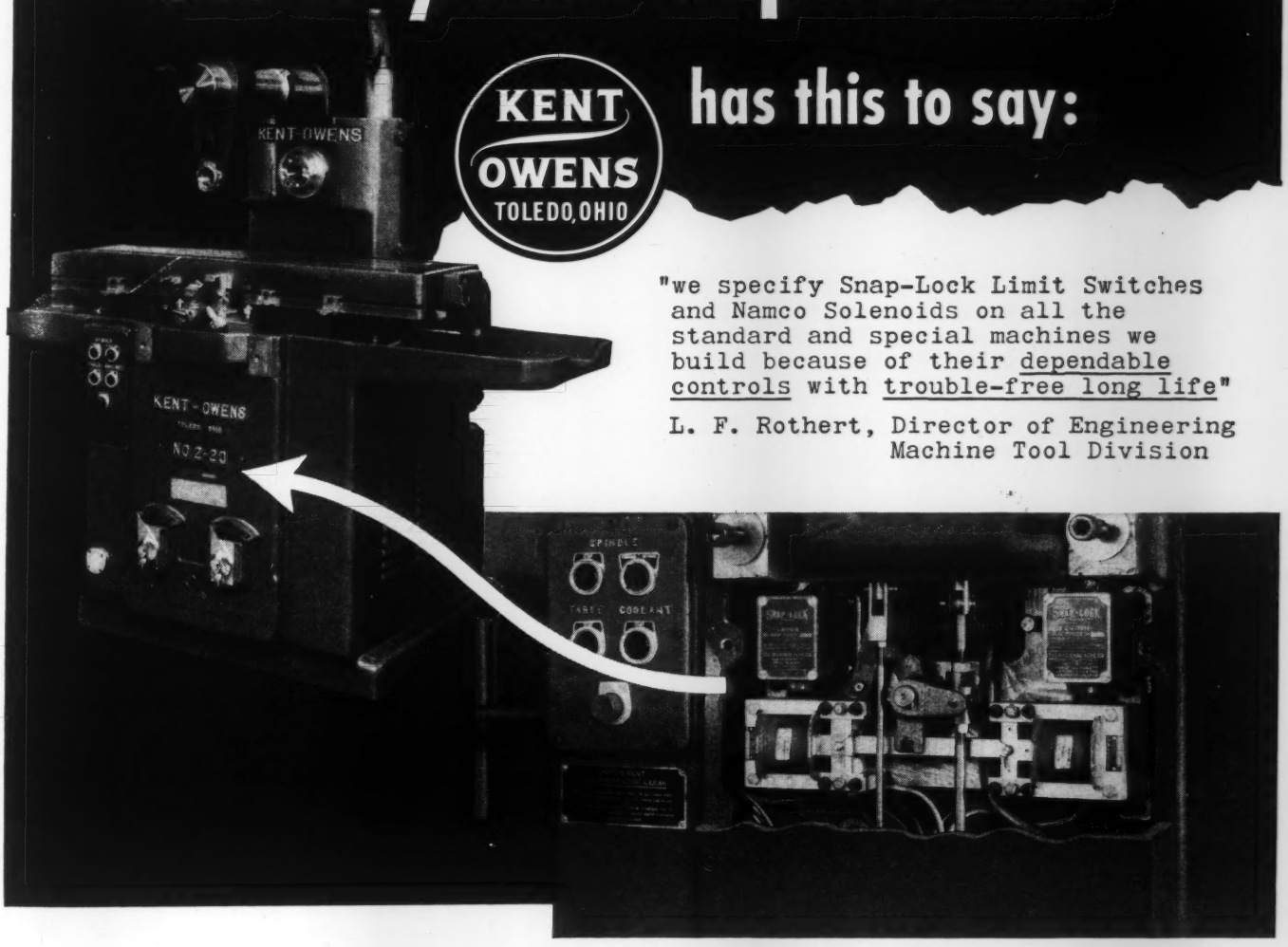

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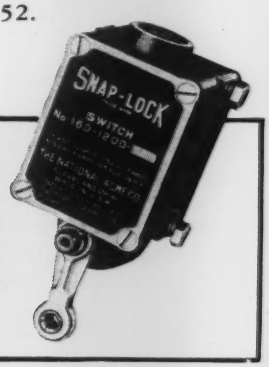

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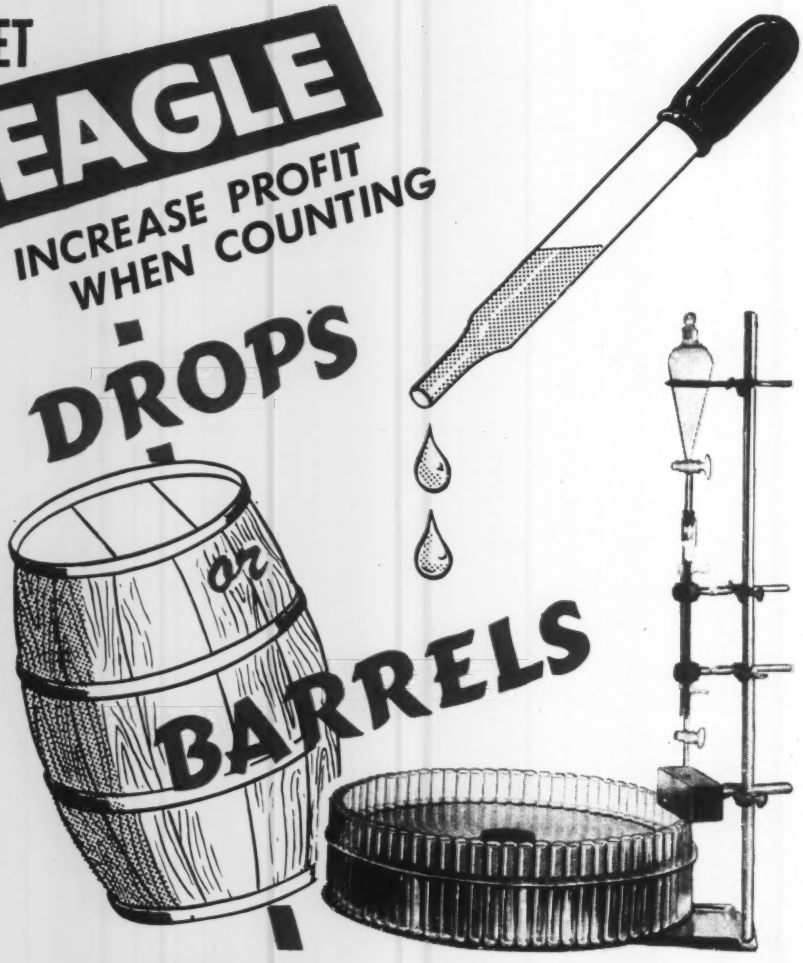
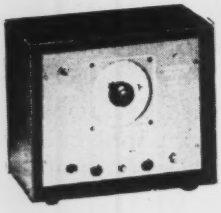
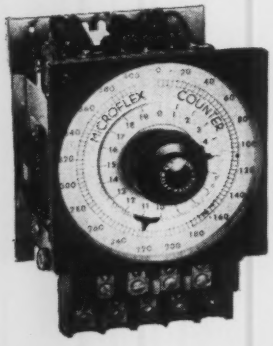




Above is an automatic fraction collector for counting and placing an exact number of drops in each of the glass vials. The heart of the control unit, shown at the left, is an Eagle Microflex Counter, which insures accuracy and dependability.



If your problem is counting liquids in any quantities from drops to barrels, the Eagle Microflex Counter will eliminate guesswork, speed up operation, and make many processes completely automatic. The Microflex Counter closes or opens a circuit after a pre-set number of impulses, adjustable from one to four-hundred.

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yet be so interlocked as to ensure that both hands must be used. Pedal control is definitely dangerous because of the ever present risk of unco-ordinated action of foot and hands. For absolute safety, pedal controls should be replaced by two hand devices designed to prevent misuse. Where more than one operator is employed on the same machine, multicontrol is essential.

From a paper entitled "Fundamental Principles of Machine Guarding" presented at the National Safety Congress in Chicago, Ill., October, 1953.

Electrodynamic Braking of Squirrel-Cage Motors

By Samuel Noodleman

Manager
Standard Electric Div.
Standard Dayton Corporation
Dayton, O.

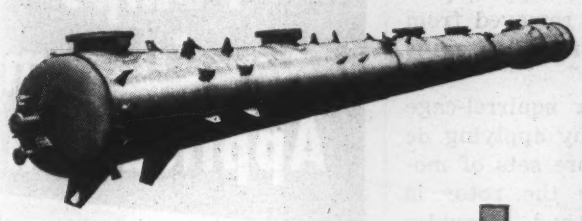
AS MACHINES increase in complexity and the requirements for machine production are increased, it becomes just as necessary to stop these machines accurately as to start and carry loads. The problem of stopping electric motors is important to the machine designer and many methods have been developed to meet this requirement. There are certain methods of braking which are associated only with ac squirrel-cage motors. These methods involve the use of a magnetic field only for obtaining the braking action of the motor.

A new development in this field is an ac electrodynamic brake motor. In this design the motor is a conventional squirrel-cage motor with a standard type stator winding and a special winding which provides braking whenever it is energized directly from an ac line.

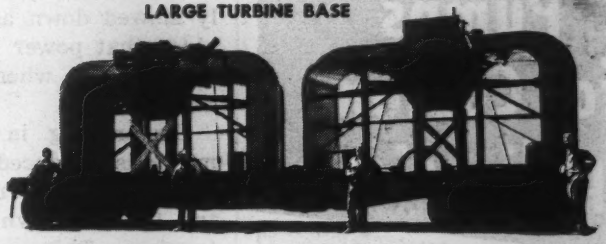
Braking Torques: A comparison of braking torques resulting from plugging, dc braking, and the new ac braking principal applied to a typical 5 hp squirrel-cage motor is shown in *Fig.* 1.

Plugging is accomplished by reversing one phase of a polyphase motor which causes the field to re-

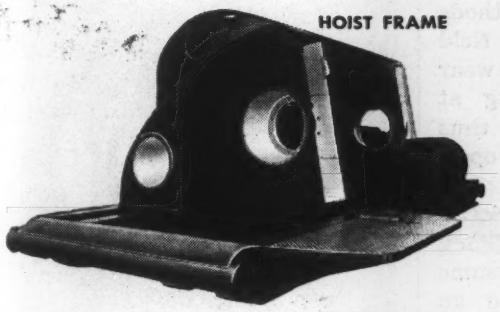
VESSEL WELDMENT



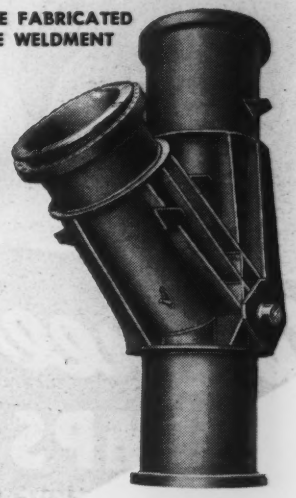
LARGE TURBINE BASE



HOIST FRAME



LARGE FABRICATED PIPE WELDMENT



Struthers Wells does the whole job on simple or complex

Weldments

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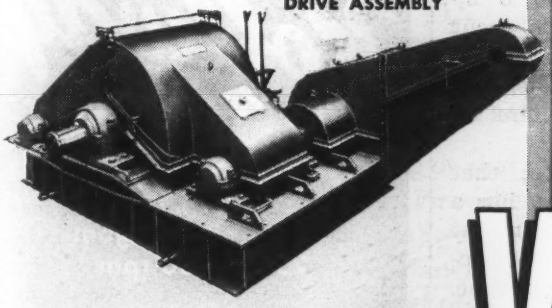
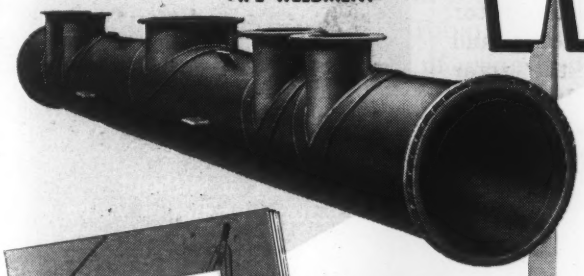
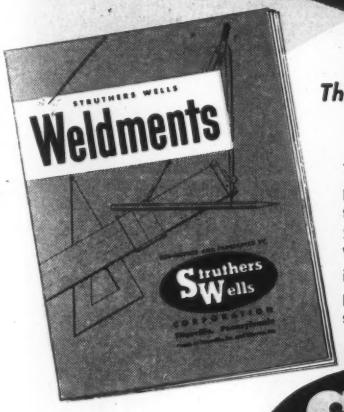


LARGE FABRICATED PIPE WELDMENT





This Brochure gives the facts

Technical data plus many illustrations of typical Struthers Wells Weldments are included in 16 pages. May we send a copy?

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DETROIT HARVESTER Company

PIONEER PUMP Division

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(FACTORY Paris, Kentucky)

Design Abstracts

volve in the opposite direction from the rotor. Thus, the rotor is rapidly slowed down and stopped, provided that power is removed from the winding when rotor speed is zero.

Dc braking in a squirrel-cage motor is produced by applying dc power to one or more sets of motor terminals while the rotor is turning. This method provides a smooth braking stop without reverse rotation. All three methods of braking utilize a magnetic field to provide stopping without wear and without positive locking at zero speed. These methods thus differ inherently from the operation of mechanical brakes.

In comparing the characteristics of these three methods of stopping ac squirrel-cage motors, assume that it is desired to brake an inertia (Wr^2) load of 3lb-ft^2 which is approximately twice the rotor inertia of a typical 5 hp motor. The plug stop would occur in 0.7-second, the dc brake stop would occur in 1.3 seconds, and the new ac stop would require 1.0 second.

It is interesting to note that even though the ac braking has a higher average torque than the other two methods it does not provide the quickest stopping time. However, for a plugging stop, the rotor would revolve 10 revolutions; during the dc braking, the rotor would make 26 revolutions; and for ac braking action the rotor would revolve 8 times. It is characteristic of the ac braking prin-

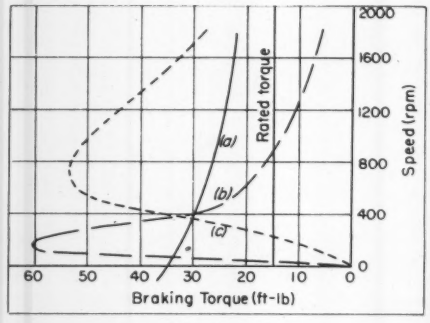

Fig. 1—Braking torque comparisons of plugging (a), dc braking (b), and ac braking (c) applied to 5 hp, 1800 rpm, 3-phase, squirrel-cage motors. Average braking currents required were 81, 28, and 27 amp for *a*, *b*, and *c*, respectively

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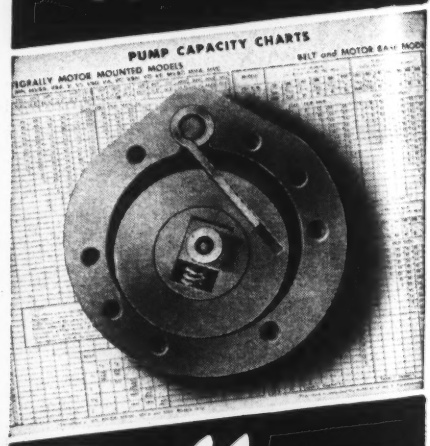

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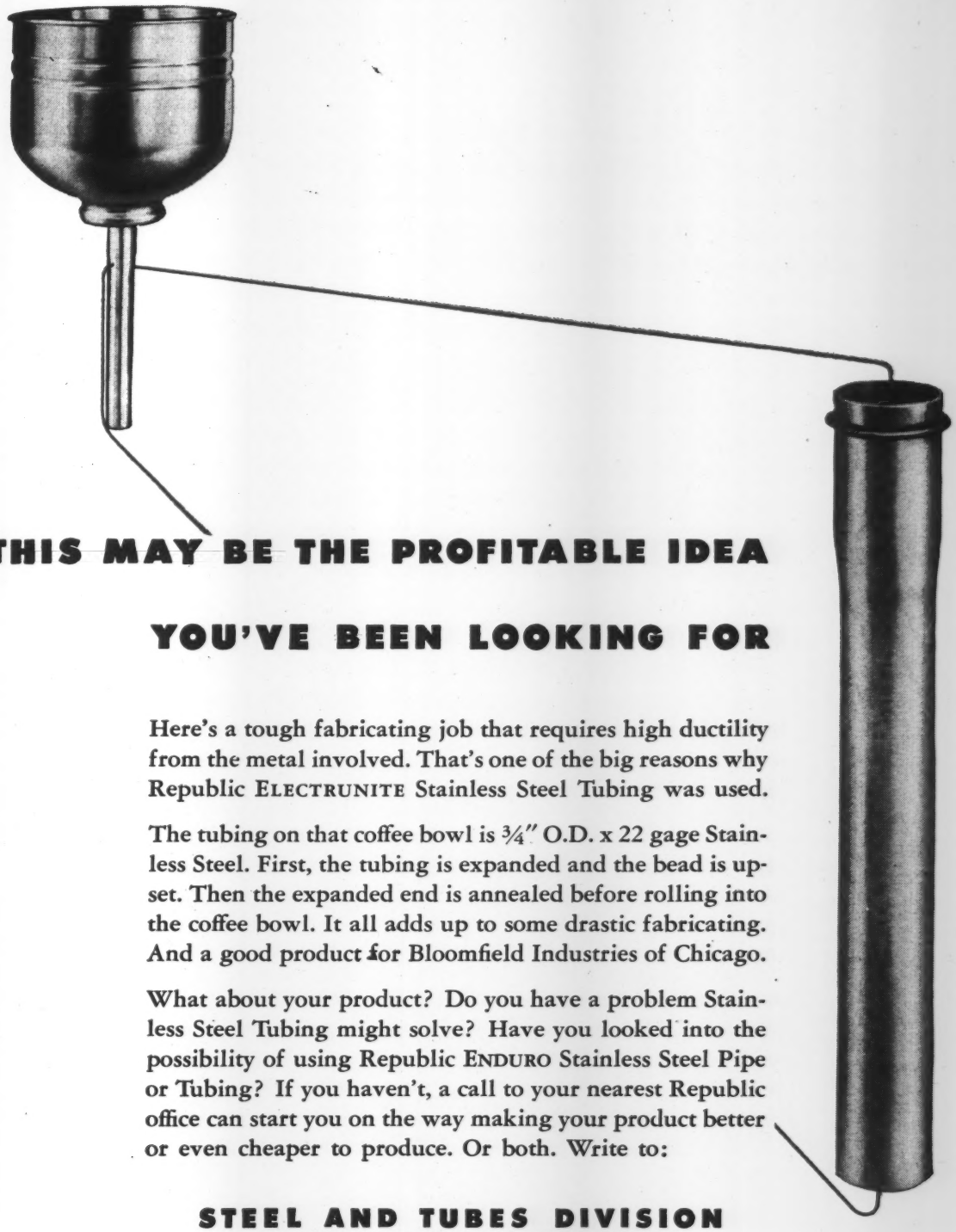

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Kentanium is available in standard extruded shapes, simple molded forms, and intricate designs. Our engineers will be glad to work with you in determining how Kentanium can best be applied to your high temperature problems.

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ciple to require a longer braking time as compared with the plugging stop for comparable average braking torques. However, the number of revolutions which the rotor makes during ac braking is less. Another desirable characteristic of the ac electrodynamic principle is the rolling type of stop provided as zero speed is approached.

Electrical Design: The general physical construction of this new ac electrodynamic motor consists of a two-phase, multipolar winding superimposed upon a standard motor winding. This two-phase winding is designed to be noninductively coupled with the main motor winding and, consequently, when the motor winding is operating, no losses are incurred from the two-phase winding. One phase of this brake winding is shorted while the other phase is connected to the ac line during the braking process. Dynamic braking action occurs when the rotor is rotating above the synchronous speed of the multipolar brake winding because energizing this winding provides the exciting current necessary to make the rotor feed power back into the line. Thus, rotational energy driving the rotor is converted into rapid braking torque. As the rotor approches the synchronous speed of the brake winding, energy is fed from the rotor into the short-circuited phase which is 90 degrees away from the exciting phase. The rotor transfers its energy from induction generator action, which feeds power back into the line, to that of feeding power into the short-circuited phase while continuing the braking action down to zero speed. Since this transfer of energy occurs automatically as the rotor slows down, the braking action is produced smoothly and continuously from full motor speed down to zero.

The short-circuited phase of the brake winding is wound with a few turns of heavy wire which provides a rugged winding. The energizing phase of the brake winding is wound to meet line voltage requirements.

While the braking winding is generally designed for the required

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Torrington Needle Bearings have become "standard equipment" throughout industry since their introduction nearly twenty years ago.

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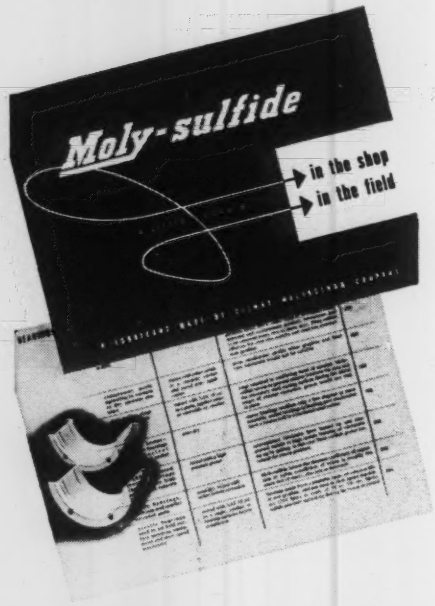

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Design Abstracts

braking performance, its braking torque can be readily reduced. Since the braking torque varies as the square of the voltage, resistance inserted in the braking winding line will provide braking as soft as desired.

Applications: The new ac braking motors can be used on drill presses or milling machines where it is often desirable to obtain a quick stop in order to permit tool changes or to prevent damage of work. These machines generally have a high ratio of inertia to friction and consequently high braking torques are required to provide the desired stopping. The rolling action of the new design is employed to advantage in many instances to provide easy transfer of gears.

The new motor design has been also successfully applied for the head-stock drive on universal grinders. This application requires not only the quick braking of the milling machine, but also must provide sufficient braking capacity so that inching and jogging operations can readily be made without causing overheating. Other successful applications include drilling and tapping machines, automatic winding machines, and automatic table positioning on jig borers.

From a paper entitled "The AC Dynamic Brake Motor" presented at the Sixth Annual AIEE Conference on Machine Tools in Cleveland, O., October, 1953.

Pertinent Facts about Titanium

By Julius J. Harwood

Head, Metallurgy Branch
Material Sciences Div.
Office of Naval Research
Washington, D. C.

ONE of the most widely publicized metallurgical developments of the past decade has been the introduction of ductile titanium. The "wonder metal," the "Titan of metals," and other equally glamorous terms applied to titanium are evidence of the excitement it has stirred. Although continued study has sobered early

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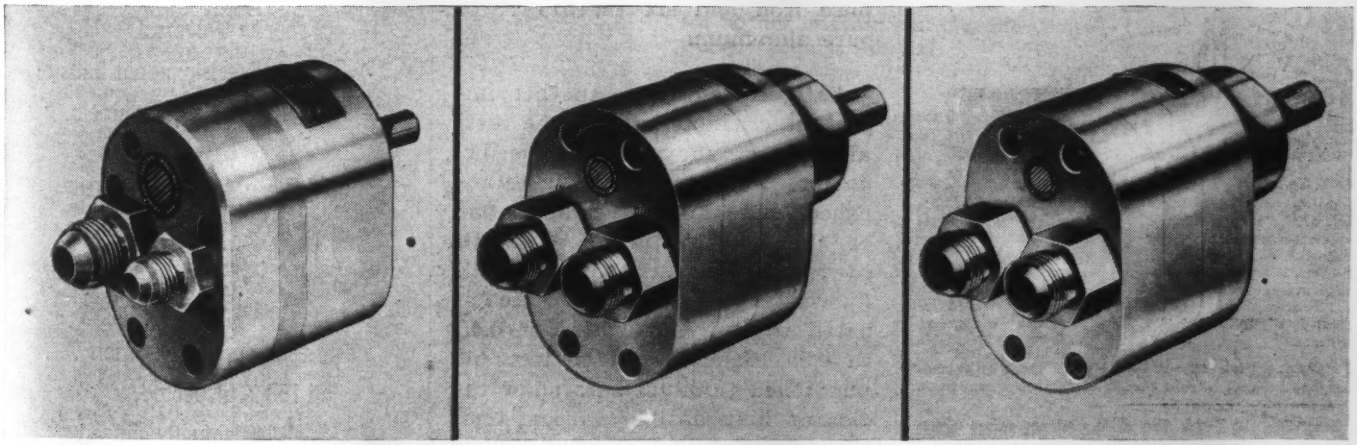
Design engineers have confidence when they specify dependable Eastern Hydraulic Pumps and Fluid Motors. Exclusive Eastern features create an economical, reliable, and compact unit for the heart of your hydraulic mechanism.

Lightweight construction of aluminum alloy housing, nitralloy gears and shaft, and close tolerances assure longer service, higher volumetric efficiency, and more dependable operation. Various types of mountings are available for space saving installation.

In many cases by specifying an Eastern unit you realize dollar savings as well as great savings in size. They cut operating costs by keeping space requirements and weight to a minimum.



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700 Series — High pressure gear pump. Delivery from .6 to 9.6 gpm and pressures up to 1,500 psi.

2700 Series — Gear type fluid motor. Torque output — 0 to 15 ft. pounds.

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QUICKLY AND EASILY
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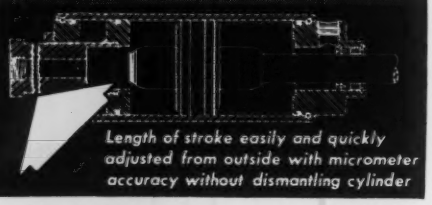

Length of stroke easily and quickly adjusted from outside with micrometer accuracy without dismantling cylinder

You don't pay for special patterns . . . and you don't have to use a cylinder that's not quite "right" for the job when you choose the O-M Cylinder. Since nearly all parts are standardized in O-M Cylinders (plus one or two semi-standard parts), the additional cost is extremely small when you need a duplex, triplex, adjustable-stroke, tandem—or any other "special" type cylinder for applications not suited to standard units.

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Design Abstracts

overenthusiastic claims for the metal, there is no doubt that the future position of titanium in the metal industry is firmly established.

Strength-Weight Ratio: What are the characteristics of this metal that have inspired the widespread interest in its engineering development and exploitation? One of the most significant is the high strength-weight ratio of titanium and its alloys. Even in the unalloyed state it compares favorably with most well-known structural metals and alloys. But intensive development has produced alloys with strengths twice that of unalloyed annealed titanium, and continued study may result in useful alloys with much greater strengths up to 200,00 psi. These alloys exhibit strength-weight ratios significantly higher than that of high-strength aluminum alloys and closely approaching or equal to the values for high-strength quenched and tempered alloy steels. Comparing equal volumes of material, commercially pure titanium has twice the strength of pure iron and six times that of pure aluminum.

Fatigue Behavior: Another important characteristic of the metal and its alloys is fatigue behavior. It has now been established that titanium exhibits one of the highest fatigue strength to tensile strength ratios of all known structural metals. As compared to ratios for steel of 0.45 to 0.55, flexural fatigue tests of unnotched titanium bars show ratios as high as 0.8 at room temperature. In addition, the fatigue properties of titanium alloys are considerably superior to high-strength aluminum and magnesium alloys and to many commercial alloy steels. The notch-fatigue performance of titanium also shows up favorably. Even at temperatures as high as 1000 F, titanium alloys exhibit fatigue strengths equal to at least one-half of their tensile strengths.

Toughness: Like steels, titanium and titanium alloys exhibit

who said the earth is round?

By comparison with Universal Precisioneered Balls, the earth is as out-of-round as a grapefruit!

Quality-control throughout holds Universal Precisioneered Balls to tolerances of ten-millionths of an inch.

Where high speeds, noiseless operation, and minimal torsional resistance are musts, specify Universal Precisioneered Balls of chrome or stainless steels.

Universal Balls are also made in all standard grades in chrome, stainless, bronze, solar, aluminum, and special materials . . . all 100% inspected, all individually gauged.

For special instrument applications, we produce balls guaranteed accurate within .000005".

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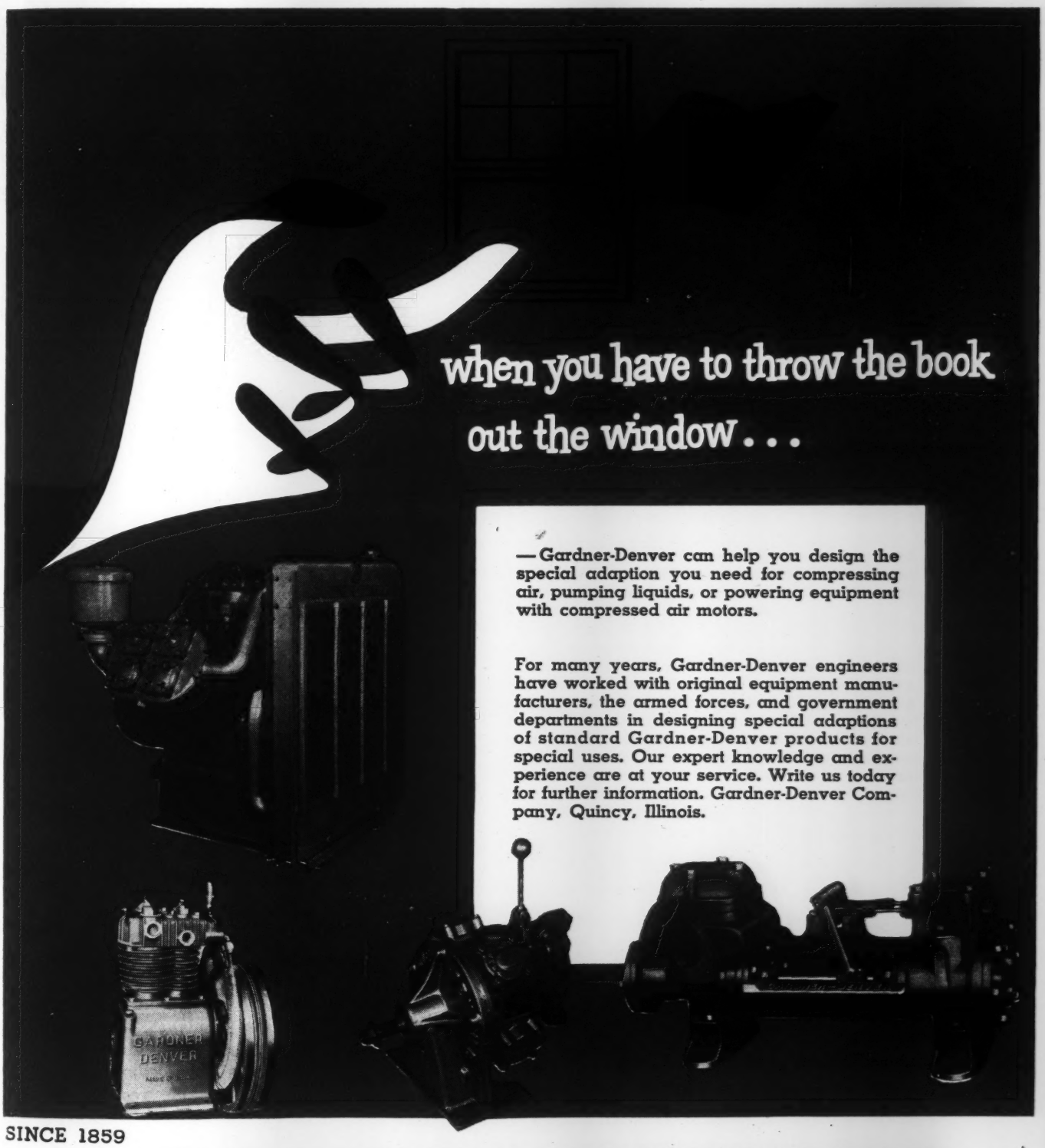
MONTGOMERY CO., PA.



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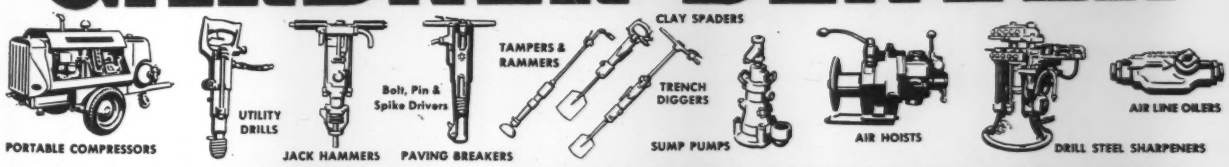

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FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

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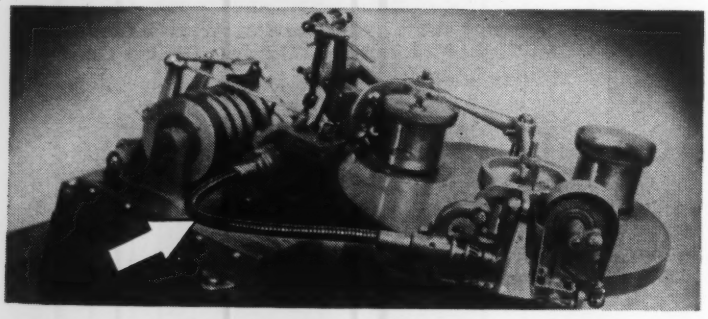
THE PROBLEM

TO TRANSMIT POWER AROUND A TURN

The designer of the machine you see below was faced with the problem of transmitting power around a 90° turn. He might have done it with bevel gears, shafts and bearings — with systems of universal joints — or possibly with belts and pulleys. Any one of these methods, however, would require a number of extra parts, additional machining and assembly operations and rigid, accurate mounting. That's why he chose —

THE LOW-COST SOLUTION—AN S.S.WHITE POWER DRIVE FLEXIBLE SHAFT



which meant fewer parts, eliminated the need for accurate alignment, simplified assembly operations, and resulted in **substantial savings in manufacturing and assembly costs.** Let S.S.White engineers show you how flexible shafts can cut costs on your own power drive applications. Their help will save you time and effort and entails no obligation.

The Design Engineer's Flexible Shaft Bible

This 256-page flexible shaft handbook has complete details on flexible shaft selection and application. Copy sent free if you request it on your business letterhead.

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DENTAL MFG. CO.
Dept. 4, 10 East 40th St.
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

a transition from ductile to brittle behavior at low temperatures, but the change-over temperature for titanium is considerably higher than for most steels. However, unlike steels, within the so-called brittle fracture range, even at temperatures as low as 100 F, titanium alloys exhibit an appreciable impact resistance or toughness characteristic. Alloys which exhibit remarkable impact properties, even at subzero temperatures, have led to serious consideration for ballistic and armor plate applications. In general it can be stated that titanium exhibits useful engineering toughness characteristics from −100 to 600 F and higher.

Corrosion Resistance: From a naval point of view, one of the most remarkable assets of titanium and its alloys is the complete inertness to marine environments. After much testing, it has been concluded the marine corrosion resistance of titanium is unsurpassed by any of the common structural materials and is equalled only by the precious metals and Hastelloy C. Titanium is highly resistant to quiescent sea water as well as to water moving up to 27 feet per second. Rotating spindle tests in sea water at speeds of 1,140 rpm (peripheral speeds of 26 feet per second) for more than 60 days indicated negligible corrosion attack. Although titanium fouls in sea water, no pitting has been observed; other strenuous corrosion tests produced the same results. In cavitation-erosion tests, titanium was almost equal to the best of a series of alloys which were considered good marine propeller materials.

Titanium has excellent resistance to nitric acid of all concentrations, including fuming nitric acid at all temperatures up to the boiling point. It is resistant to dilute solutions of sulfuric and hydrochloric acids up to 100 F and with iron or copper salts as inhibitors, it can be used in more concentrated solutions of sulfuric acid and hydrochloric acid up to

the boiling point. Titanium is exceptionally resistant to aqua regia, ferric and copper chlorides, and strong bleaching agents containing hypochlorites. It has also exhibited outstanding resistance to contact and crevice corrosion and intergranular corrosion. Only red fuming nitric acid has been found to produce stress-corrosion cracking in titanium. These and many other chemical and corrosion characteristics indicate that the metal will be useful in numerous applications now requiring highly alloyed and expensive materials or frequent maintenance.

Temperature Properties: The high-temperature properties of titanium are intermediate between those of aluminum and steel, and the strength-weight ratio offers opportunities for appreciable weight savings. Consequently it may be possible to substitute titanium alloys for aluminum alloys, steels, and stainless steels in appropriate applications where weight saving and temperature resistance are of major importance. So far, investigation of titanium alloys indicates that 800 F is the upper temperature limit at which useful engineering properties still exist. However, alloys now in the development stage may raise this limit to 1000 F. Some of the temperature limiting features are poor oxidation resistance above 1200 F and the embrittling effects of oxygen and nitrogen at these temperatures.

Availability: Just as important as these outstanding characteristics is the question of availability and production of titanium. Although difficulties are encountered when it comes to extracting the metal from its ores, in actual quantity titanium is the ninth most abundant element and comprises about 0.65-per cent of the earth's crust.

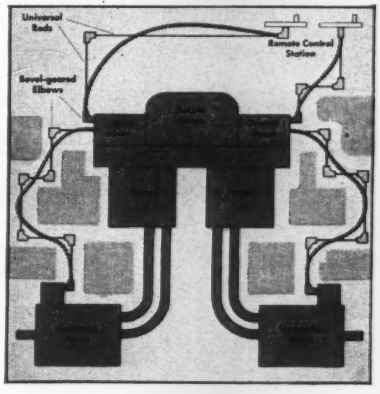
Machinability: In machining characteristics, titanium closely resembles the stainless steels. In the early stages of development, much difficulty was experienced in machining. However, by using

THE PROBLEM

TO CONTROL A DUAL HYDRAULIC POWER SYSTEM

An equipment manufacturer using the hydraulic system pictured below had to provide a means of controlling the system from a centralized point. The original design, which called for a network of 17 universal rods with their bearings and 18 bevel-geared elbows, was both costly and troublesome and failed to provide the sensitivity required by the application. As a result, the manufacturer chose —

THE LOW-COST SOLUTION—AN S.S.WHITE REMOTE CONTROL FLEXIBLE SHAFT



In fact, only 4 standard S.S.White flexible shafts were needed to replace the 35 parts that were formerly used. The flexible shaft system **cost 90% less, reduced assembly time and labor, eliminated alignment problems** and **provided 100% improved performance.** It's savings like these that make it well worth your while to investigate the economies of using S.S.White flexible shafts on your own remote control applications.

Up-to-date Flexible Shaft Information

This 256-page flexible shaft handbook will be sent free if you request it on your business letterhead. It contains full facts and data on flexible shaft selection and application.

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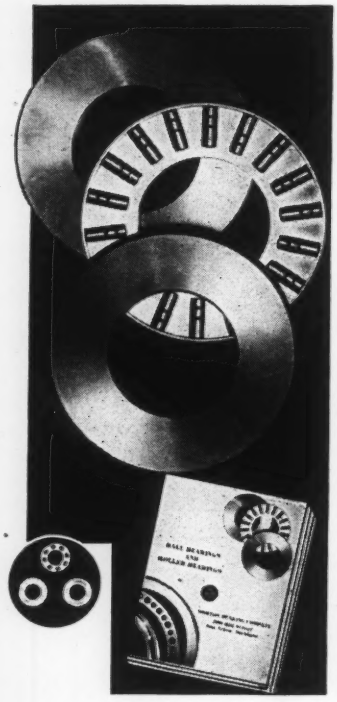

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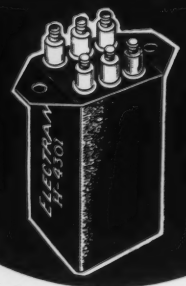

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methods especially adapted for titanium, and by the development of suitable lubricants, many of the problems are being overcome. Because of the high rate of wheel wear, titanium and its alloys are difficult to grind. Galling and seizing have been particularly bothersome problems. The ease with which titanium sticks to metal surfaces is also causing concern for some proposed applications. Intensive research is now under way for the development of lubricants and surface treatments to eliminate some of these difficulties.

Weldability: Pure titanium can be successfully welded by resistance or inert gas-shielded arc methods. Obviously, because of its reactivity, care must be exercised to prevent hydrogen, oxygen, and nitrogen from coming in contact with hot titanium, or else brittle welds will result. However, in the case of titanium alloys, ductile weldments are the exception rather than the rule. The problem of welding titanium alloys is intimately associated with the state of understanding of heat treatment of these alloys. Much research is going on to learn how to heat treat alloys so as to avoid embrittlement.

Castability: It would be highly desirable if casting techniques, similar to those used with other engineering metals, could be applied to titanium. The areas of potential application would increase manifold if shapes of titanium could be cast directly, not to mention the reduction in price if costly machining and fabricating processes could be eliminated. As is the case with melting titanium ingots, contamination is a terrific problem. Molten titanium reacts with all known crucible and mold materials, and vacuum or inert atmospheres must be used.

The most promising method which has been developed to circumvent these problems is the "skull-melting" process in which titanium actually is melted within itself. Water-cooled copper or nonmetallic (graphite or ceramic) crucibles are lined with a shell or

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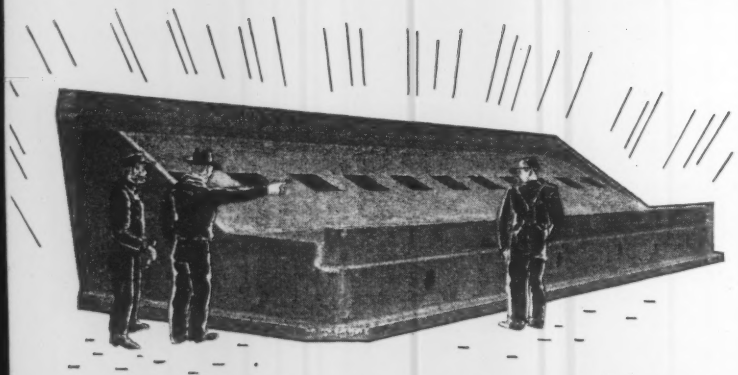

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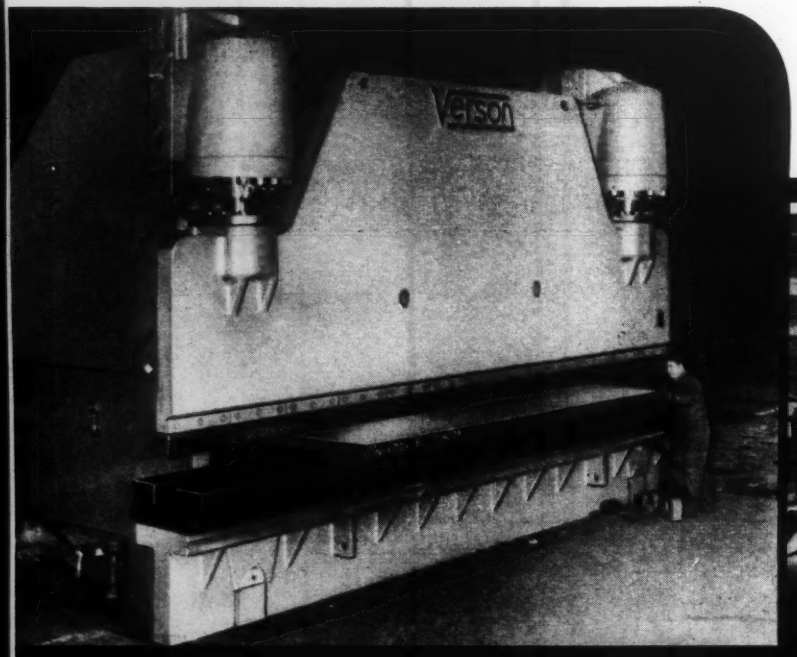

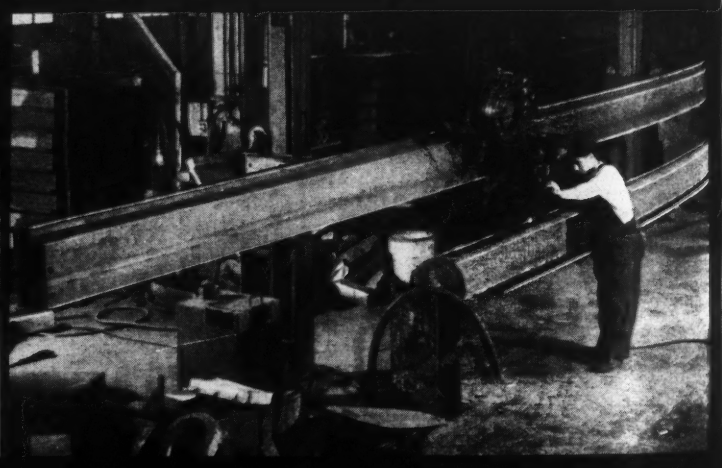

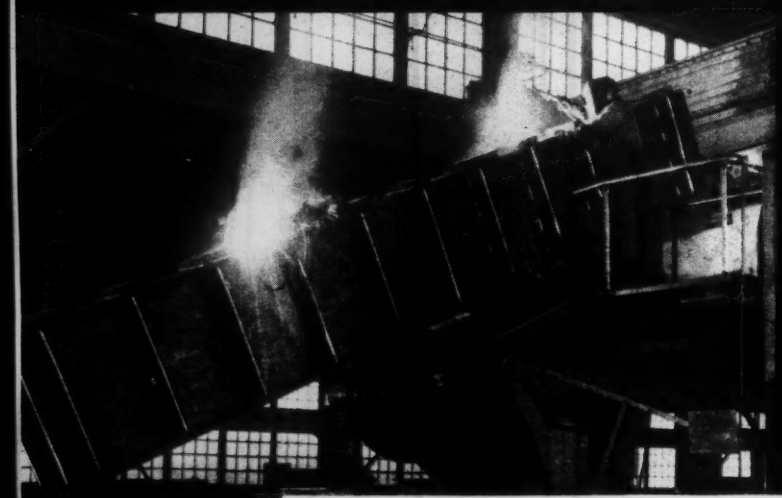

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Division of

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REPUBLIC

skull of solid titanium. This skull holds the molten pool and reduces pick-up of embrittling impurities. Arc-melting techniques are employed with skull melting and the molten pool within the skull is then poured into a mold. The pouring operation is often done within the arc furnace so that the entire melting and casting procedure is carried out under vacuum or inert atmospheres. Because of the rapid heat transfer of the water-cooled copper container, only a limited amount of metal is molten at any time and only small castings can be made.

Titanium Castings

Castings ranging from 10 to 100 pounds have been produced by skull-melting techniques with interesting properties. Mechanical properties have compared favorably with wrought alloys of similar compositions. Carbon pick-up has been held down to nondetrimental amounts. Skull-melting techniques are being applied also to the production of ingots, and it appears that the method will be developed into a useful commercial process.

Powder Metallurgy: Despite the minor attention being given to the processing of titanium by powder metallurgy, methods have been developed by at least one industrial concern for pressing titanium compacts to theoretical density. Recent tests have indicated that such compacts exhibited properties equivalent to those of arc-melted material. This pressing operation is now being expanded for the production of titanium ingots, and sizeable ingots have already been produced on an experimental scale.

It seems reasonable to expect that applications exist for titanium alloys for which appropriate use of powder metallurgy processes may solve fabricating problems. By resorting to direct pressing methods and thereby omitting the cast ingot and subsequent processing stages, it seems conceivable that the present high cost of some titanium products could

(*Continued on Page* 330)

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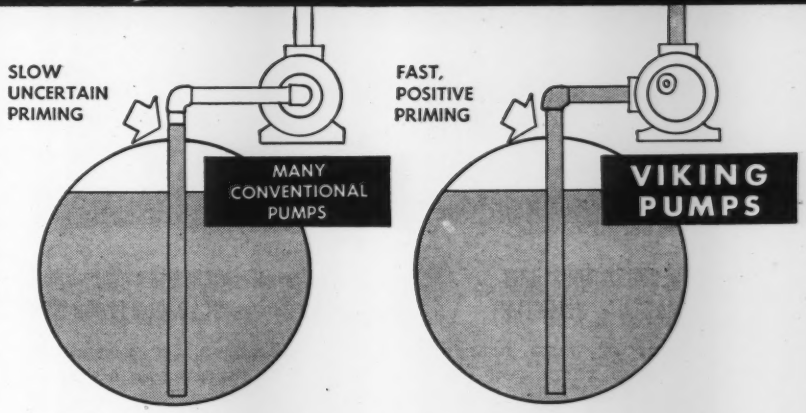

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These photographs are representative of the tremendous Reynolds fabricating facilities . . . facilities that make possible seven basic economies to every manufacturer who uses Reynolds Aluminum Fabricating Service.

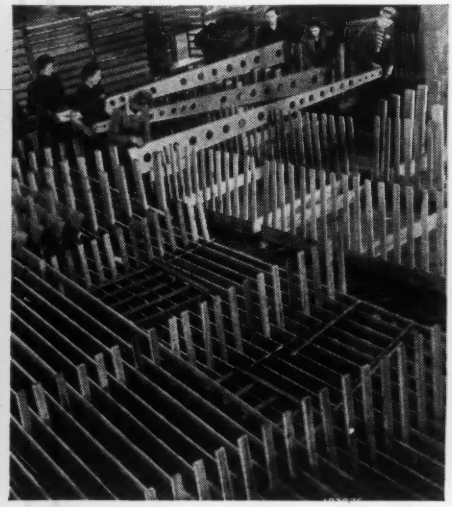
Not shown in these photographs, are two equally important advantages that Reynolds offers manufacturers. One, quality and production control from mine to finished product. Two, experienced design and engineering service.

You'll see *proof* of the latter advantages—along with proof of the seven basic economies pointed out in the photo captions—in each aluminum blank, roll formed shape, completed part or final assembly you get from Reynolds.

For your present needs or for development work on future models, contact your nearest Reynolds office listed under "Aluminum" in your classified telephone directory or write for your copy of the new "Complete Facilities" catalog to Reynolds Aluminum Fabricating Service, 2061 South Ninth St., Louisville 1, Ky.

2 **Reynolds REDUCES YOUR RAW MATERIAL INVENTORY**

You get *pounds of parts* instead of pounds of metal when you use Reynolds Aluminum Fabricating Service. Like the automobile manufacturer who will receive the extruded aluminum window frames above, you can save, too, by cutting out that costly part of your metal inventory that does not go into finished parts. Over 30 Reynolds plants in 18 states are at your service!



3 **Reynolds RELEASES YOUR VALUABLE FLOOR SPACE**

Pictured above are just a few of 6,000 *different parts* for a single plane in production at Reynolds plants at one time during World War II. Imagine the floor space required for this production. Imagine the floor space *you* can save in *your plant*—space you can put to profitable use—when you call on Reynolds Aluminum Fabricating Service to turn out aluminum parts for your products.

4 **Reynolds ADDS TO YOUR CAPACITY WITHOUT INCREASING COSTS**

Here, in the photograph above, aluminum TV antenna is being formed on one of the seventeen Reynolds roll forming machines. The great variety of Reynolds specialized equipment enables you to obtain the economy of the machines best suited to your purpose, without making the tremendous capital investment in equipment and added plant capacity which would otherwise be required.

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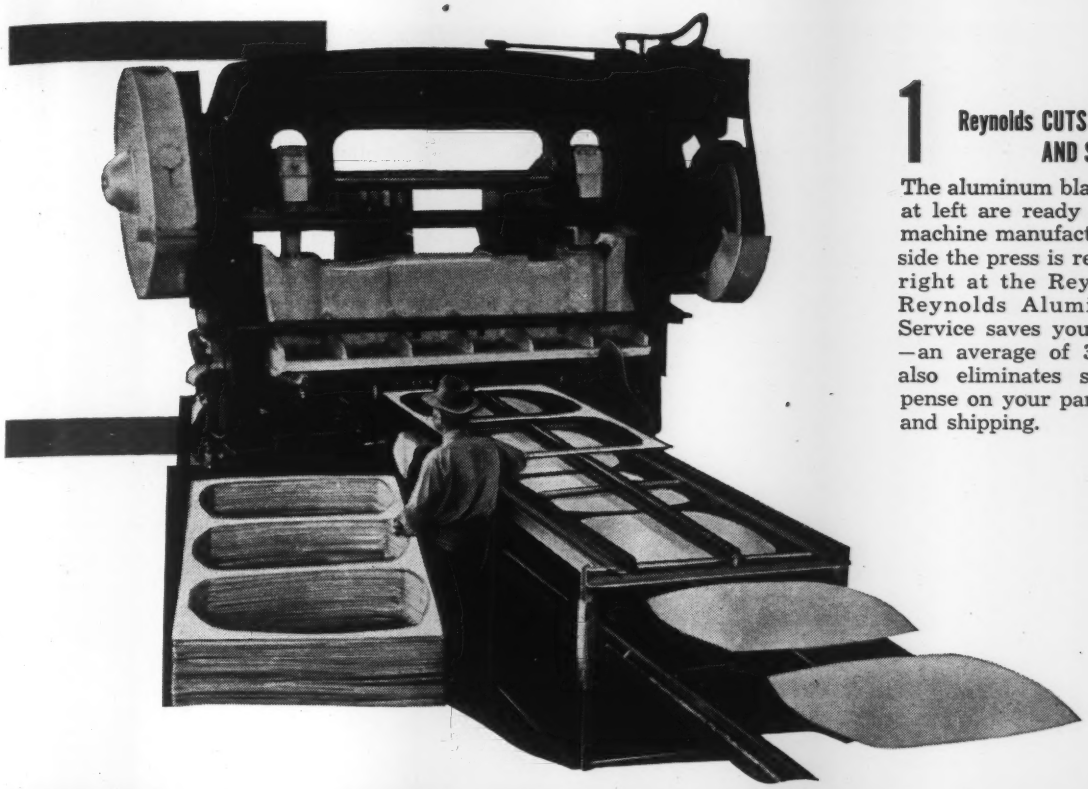
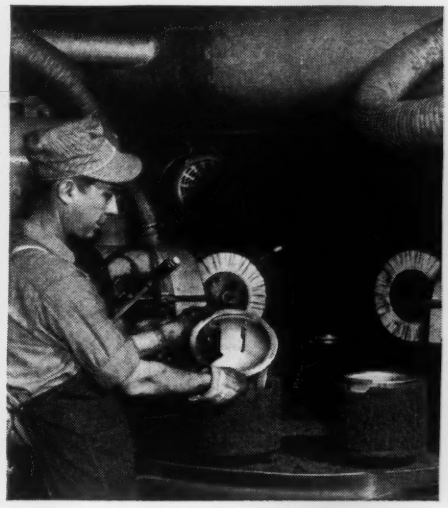


1 Reynolds CUTS YOUR SCRAP LOSS AND SCRAP HANDLING COSTS

The aluminum blanks on the conveyor at left are ready to go to a washing machine manufacturer. The scrap beside the press is remelted immediately right at the Reynolds plant. Thus Reynolds Aluminum Fabricating Service saves you—the manufacturer—an average of 30% scrap loss and also eliminates scrap handling expense on your part in sorting, storing and shipping.

5 Reynolds CUTS YOUR MATERIAL HANDLING COSTS

The aluminum pallets above will reduce material handling costs in many plants . . . and the manufacturer of these pallets is also reducing *his* material handling costs by getting *pounds of parts*, not pounds of metal, from Reynolds Aluminum Fabricating Service. Reynolds also takes the problems of scheduling, material supply, labor and machine availability off his—and your—hands!



6 Reynolds RELEASES YOUR WORKING CAPITAL

When you use Reynolds Aluminum Fabricating Service you receive 100% of your aluminum in finished parts. And, as these parts are generally assembled into finished products before invoices come due, no investment is tied up in raw metal. These quality parts, like the shells of the aluminum cookers being buffed above, are available in a wide choice of finishes including color-anodized.

7 Reynolds ELIMINATES YOUR REJECT COSTS

Reynolds Aluminum Fabricating Service does away with your machine and labor production losses and inspection expense in rejects, because you pay only for finished, inspected parts. The conveyor line above, where refrigerator door trays are carefully inspected before packing and shipping, is just one of the many examples of Reynolds quality control from mine to finished product.

See "Mister Peepers" Sundays on NBC-TV. Consult local listing for time and station.

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"Wonder drugs" for ailing contacts

New metal powder combinations are the "wonder drugs" for treating electrical contact ills.

Molded silver-graphite quickly cures chronic cases of premature contact failure.

Silver-tungsten, silver-iron oxide, copper-graphite, silver-lead oxide and various others work wonders in other instances.

But "wonder drugs" themselves are only part of the story!

Very often, improvement depends as much on the way these contact materials are produced as on the materials themselves. Contacts of identical metallic composition may be given widely different properties. Stackpole "know how" in achieving desirable properties accurately is, we believe, equally noteworthy to the Stackpole pioneering of various contact "wonder drugs" or the Stackpole facilities for producing them all.

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Helpful Contact Data

Stackpole Bulletin 12 contains a wealth of helpful data on modern contact materials and their uses.

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Design Abstracts

(*Continued from Page* 327)

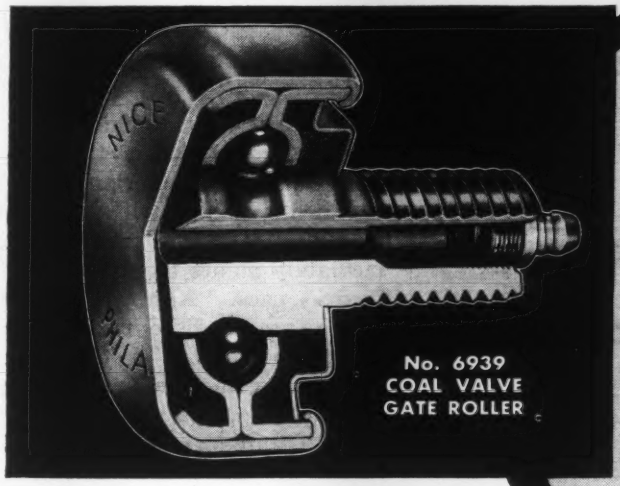
be reduced substantially.

Military Applications: In spite of difficulties encountered in processing titanium, the end product makes the effort definitely worthwhile. Titanium is a "natural" for many military uses. In faet, it is anticipated that for the next several years practically all the titanium production will be used in military applications—for prototype evaluation and for production items. Such requirements for 1954 have been announced as 25,000 tons. Because of the high strength-weight ratio and mechanical properties at temperatures as high as 800 F, primary large-scale use of titanium and its alloys will probably be found in the aircraft industry. In many cases, the weight saving and high temperature properties of the alloys offset the present high cost.

Titanium has proven an excellent material for aircraft engine firewalls, shrouds, baffles, diaphragms, ductwork, brackets, and fittings adjacent to the engine and exhaust system. In the standard firewall test, both titanium and stainless steels satisfactorily withstand a 6-inch-diameter flame impingement for at least 15 minutes, with the temperature approaching 2000 F at the impingement point. Headway is also being made in applying the alloys as structural airframe components; such as, airframe skins, wing edges, ducting, aft sections, shrouds, door and panel assemblies, and many other places. The new Douglas DC-7 uses some 600 pounds of titanium, the major use being for engine nacelle coverings.

Aerodynamic heating and high surface temperatures which occur with missiles and supersonic planes almost necessitate the use of titanium alloys. The skin temperature of a jet plane flying at 1400 miles an hour may rise as high as 450 F; at higher speeds surface temperatures of missiles can rise to 900 F. Since aluminum and magnesium alloys lose their structural efficiency above 300 F plans are under way to use titanium for skins, leading edges of

THE TREND is to Product Improvement & Lower Consumer Prices...



Once again forecasters and economists tell us that supply exceeds demand and only the alert and efficient will survive the "acid test" of the new Buyers' Market.

THE TREND, therefore, is to product improvement and lower consumer prices — and experienced NICE field men and factory engineers can help you accomplish these important objectives.

- **Quality and Economy is combined in #6939 as a typical example of NICE experience and ingenuity as "Specialists in Specials." The outer tire and dust shield are of corrosion-resistant stainless steel. A felt seal retains lubricant and excludes foreign material and a grease fitting is provided for re-lubrication. Attachment is by means of the threaded stud.**

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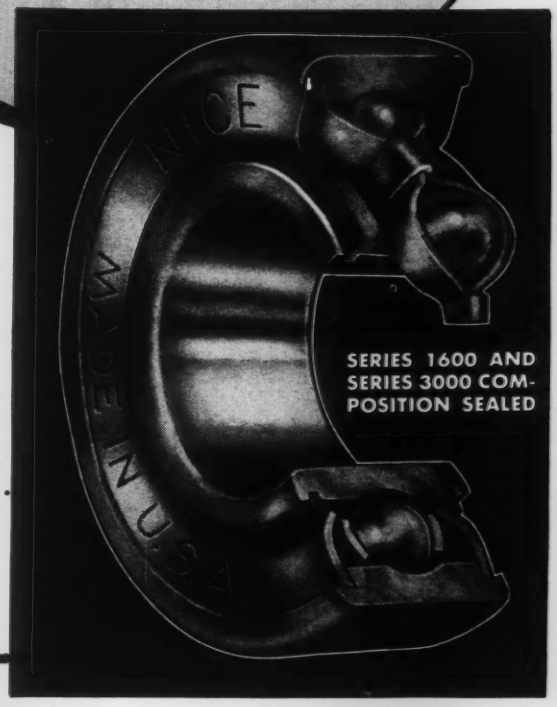
For complete information on the NICE LINE . . . . . write for Catalog No. 150.



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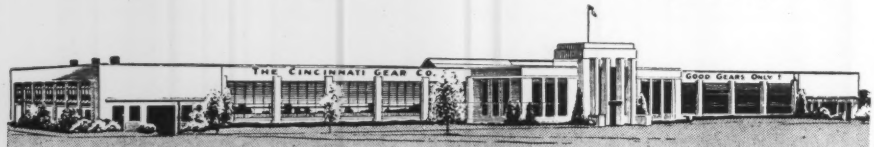

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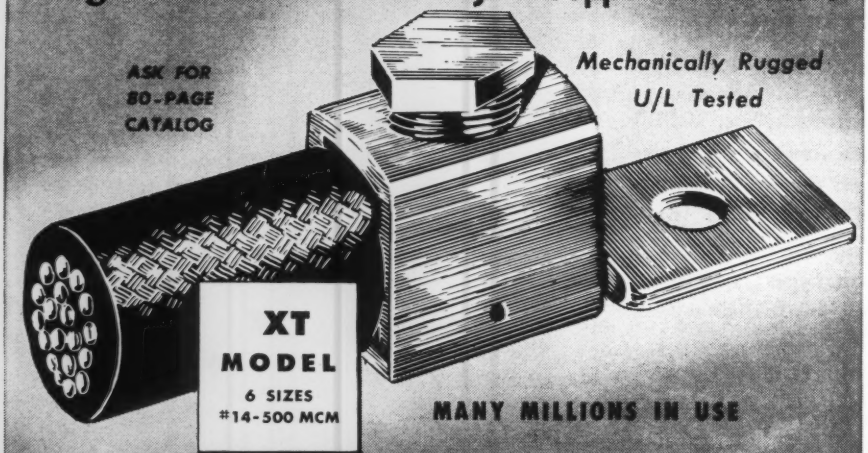

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Design Abstracts

wings and fins for supersonic aircraft and missiles.

One of the more important application developments is the use of these alloys for gas turbine compressor components — disks, blades, and stator vanes. A 300-pound weight saving, which often represents up to 40 per cent of the total weight, could be achieved by substituting titanium alloys for stainless steel in these applications. Research is also under way on titanium propeller blades and landing gear components made of titanium alloy forgings.

Marine Applications: The outstanding resistance of titanium to sea water and marine environments, together with its light weight and fatigue resistance, immediately points to extensive shipboard uses. Although present prices are a discouraging factor here, considerable prototype testing and evaluation is under way. Some of the uses being studied include titanium seats and disk trims in salt-water valves, tubing for condenser systems and heat exchangers, wet exhaust mufflers for submarine diesel engines, and turbine blades for low-temperature steam turbines. Because of its high corrosion fatigue resistance and freedom from pitting, titanium has been considered for salt-water pump shafts, small outboard propeller shafts and snorkel tubes, and as hull material for small craft such as PT boats.

From an article entitled "The Growing Promise of Titanium" which appeared in Research Reviews for December, 1953, publication of the Office of Naval Research.

Cooling Electric Equipment

By Doyle C. Wells

Ryan Aeronautical Co.
San Diego, Calif.
Electronics Engineer

COOLING environment imposed on a piece of electrical equipment in aircraft of a few years

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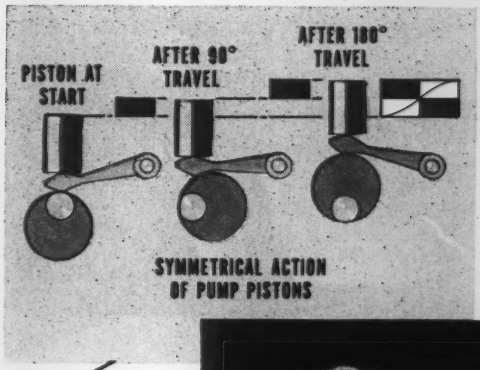
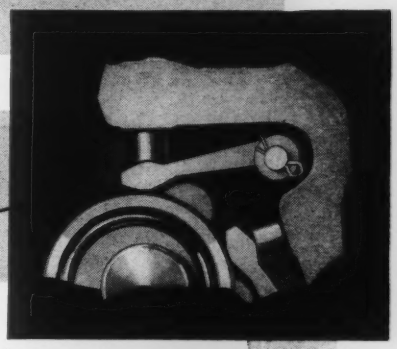
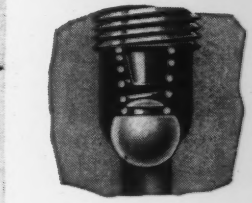
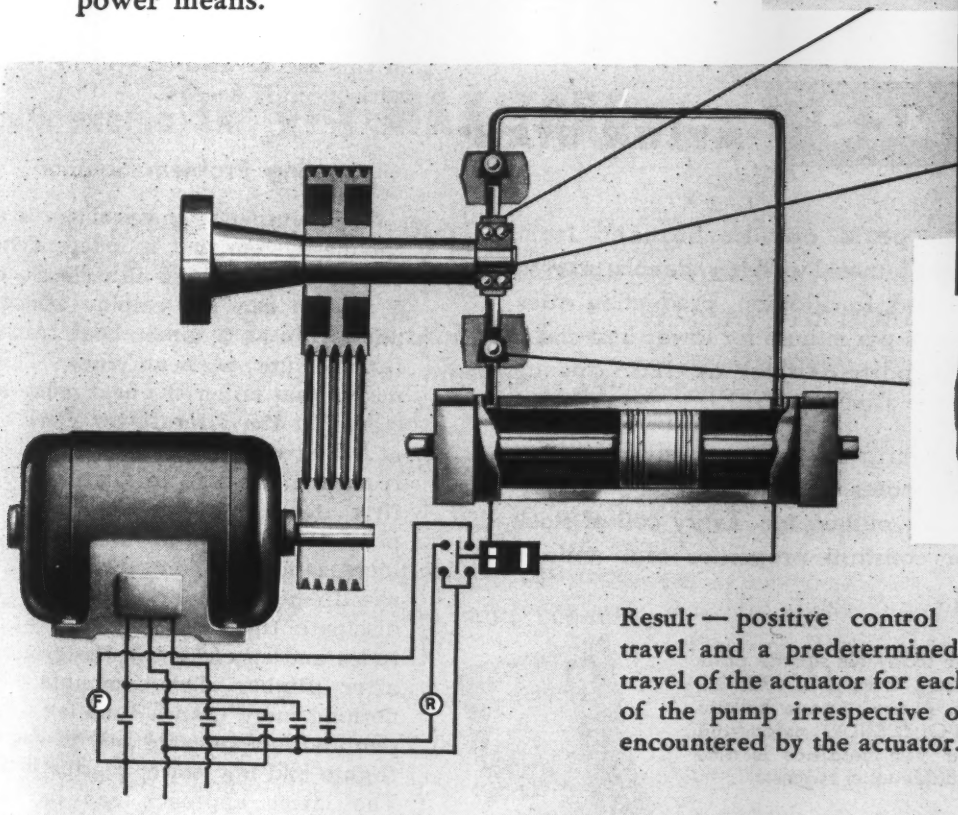
BARNES closed fluid circuit and control

Fluid circuit and power drive consist of an actuator; a variable displacement pump for propelling the actuator at selected speeds; sealed ducts leading from the actuator to the pump and from the pump to the actuator; electrical power means for rotating the pump in one direction or the other; and synchronous means for controlling the electrical power means.









Result — positive control of actuator travel and a predetermined amount of travel of the actuator for each revolution of the pump irrespective of resistance encountered by the actuator.

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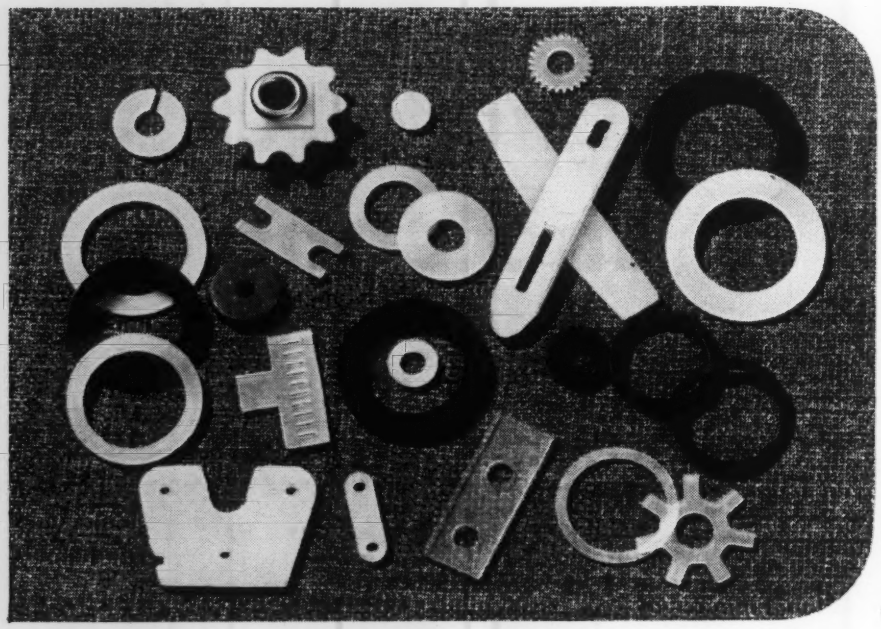

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ago was not far different than the environment of a ground or sea-based vehicle. Today, in contrast, the cooling environment has changed drastically due to higher speeds and altitudes.

Present-day aircraft handle the heat problem in two ways: (1) Air cycle refrigeration is used to reduce air temperature, and (2) equipment is built to withstand increased temperature. The first method has limitations at speeds above Mach one because of high power consumption. The second method while theoretically the better of the two, has not been attained in electronic circuits. Transformers, relays, magnetic components in general, can meet the present temperature demands while condensers, transistors, crystal diodes, and precision resistors can not. There is little or no hope of this second method keeping pace with aircraft speeds.

Cooling Problem Solution

The solution to the problem is a cooling system that is independent of aircraft speed and altitude. Such a system can not employ atmospheric air as a direct heat transfer medium or heat sink. This means that either the heat must be stored in the aircraft for ejection at a later time, or it must be ejected from the aircraft in flight. The first technique can be accomplished by allowing the heat to increase the temperature of a high specific-heat material and then dissipate this heat at lower altitudes and speeds or on the ground after flight. This amounts to nothing more than a time lag system and is applicable only to short flights and low power dissipations. The latter approach can be accomplished in several ways. The fuel used by the aircraft could be used as a coolant before it is burned in the engine. A solid could be sublimed in the presence of a liquid coolant and the gaseous products of the sublimation piped overboard. Also, liquid could be made to boil in a heat exchanger or in passages in the equipment thus absorbing heat. The gas would either be piped overboard or

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Design Abstracts

expanded for further cooling advantages if altitude permitted.

Fuel Cooling: Many possibilities are available from fuel cooling. For example, specific heat of jet fuel is about 0.6-calorie per gram or about three fourths that of water. Its effectiveness in a heat exchanger is approximately half that of water. Flow rate in a jet engine of 10,000 pounds thrust at cruising speed would amount to some 30 gallons per minute. The magnitude of allowable temperature rise of the fuel is not large, but it need not be. For a temperaure rise of 20 or 30 C, about 50 or 75 kw of heat could be dissipated. This is more than ample for any electronics combination in aircraft today.

Solid Sublimation Cooling: Sublimation of a solid does not offer as much on a weight for weight basis as either of the other two systems. Solid refrigerants while easy to use and acquire for experimental set-ups are not readily available in combat areas. By necessity, the solid refrigerant must be manufactured at its locality of use. This would not usually be practical, since quantities needed would be large and would require bulky and heavy machinery.

Heat Sink Cooling: Boiling of a liquid has moderate possibilities as a heat sink. There are many liquids that could be employed; however, none compare to water for latent heat, density, and availability. Latent heat of water is about 600 calories per gram when starting from ground temperature. This means that 1 gram of water in boiling will take with it about 2.5 kw-seconds of power. As an example, suppose a radar system of 1 kw dissipation is to be cooled. Water with a suitable antifreeze is stored in a tank as close as possible to the equipment to be cooled. A small centrifugal pump requiring about 50 watts input power would force the water through thin wall tubing brazed to the chassis of conduction-cooled equipment or through heat exchangers in pressurized equipment. The water and

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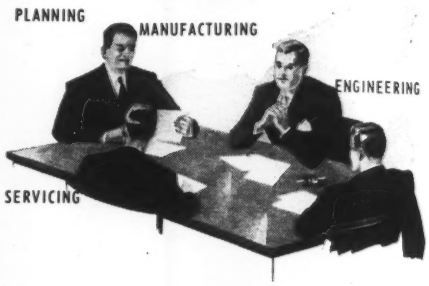

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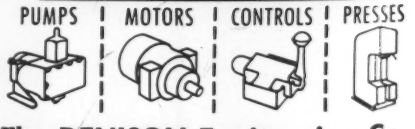
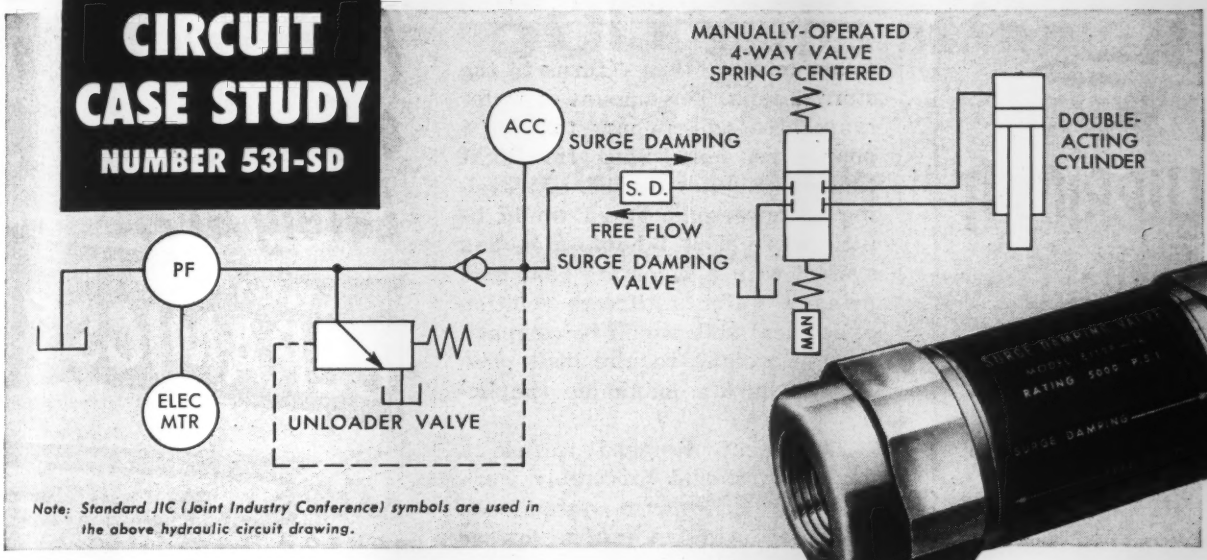
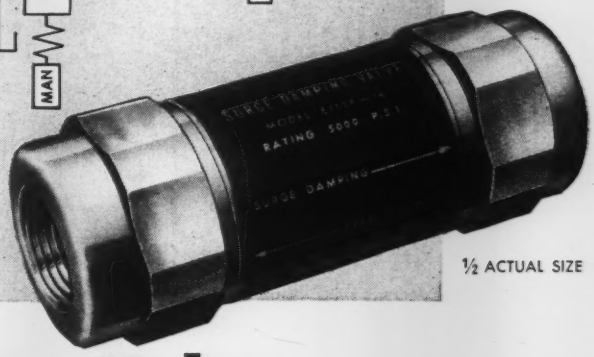


The DENISON Engineering Co.
1156 Dublin Road, Columbus 16, Ohio

CIRCUIT CASE STUDY NUMBER 531-SD



Note: Standard JIC (Joint Industry Conference) symbols are used in the above hydraulic circuit drawing.



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The circuit above shows a typical way to provide for intermittent ram action.

A relatively small pump is used, as reserve pressure is stored in the accumulator between applications of ram effort. When pressure in the accumulator reaches a preset maximum, the unloader valve diverts pump volume to the reservoir at negligible pressure.

Shifting the control of the four-way valve causes the ram to descend on the work, instantly utilizing reserve pressure from the accumulator. Ordinarily, this sudden extra volume and pressure produces hydraulic shock, which causes excessive noise and is apt to damage piping joints and seals.

The Denison **Surge Damping Valve** *prevents,* rather than absorbs, this hydraulic shock. It is a normally closed valve, but when line pressure is directed toward the inlet side, it allows a gradually increased flow of oil until fully opened. Then virtually free flow is maintained until oil flow is interrupted—no matter how briefly. The valve then resets instantly, ready for the next ram action.

Operation is simple and positive. The valve body houses a close-fitting spool which must move against and displace a cushion of oil to permit flow through the valve. As the surge of pressure strikes the spool, oil in the cushion escapes through a small orifice. Oil rushing out of this orifice is directed against a normally open flow control device. This flow control is hydraulically unbalanced; therefore, it tends to close under this pressure—the higher the surge pressure, the greater the throttling effect. In other words, speed of valve opening is inversely related to surge pressure increase.

Even under heaviest shock pressures, the valve takes only a split-second to act. In fact, tests prove it takes no longer to act than the duration of an uncontrolled shock impulse.

Denison **Surge Damping Valves** are made in both industrial and aircraft types, for pressures to 5000 psi. They require no adjustments of any kind, need no maintenance, have no moving seals, adjust automatically to any working pressure in any type of circuit, and do not interfere with other circuit functions. An integral check device provides free reverse flow.

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steam mixture then returns to the storage tank. The amount of water evaporated will amount to 3 or 4 pounds per hour. Since the flight time of a fighter capable of traveling at supersonic speed would be little more than 1 hour, a cooling system with a moderate heat load using a water antifreeze solution as its heat sink would be compact, light in weight, require little power, and have a maximum simplicity.

Equipment designed to use a heat sink should preferably work near 100 C. However, systems can easily be made to run as low as 80 C. Such a system would incorporate a centrifugal blower to produce a vacuum on the heat sink at low altitudes. This blower would require speed control if a constant temperature in the heat sink were desired. Otherwise, it could be left free to run until a preset altitude was reached, then it could be shut off. A spring-loaded, bypass valve could regulate the temperature at all higher altitudes. In most cases heat inertia of the liquid would be adequate to keep the temperature of the system below maximum boiling temperature until the airplane climbed above the minimum altitude needed to maintain this boiling-temperature equilibrium. Each specific system would have details that would have to be worked out to meet the requirements of the equipment to be cooled.

Liquid and Gas Cooling: In certain electrical equipment, an inert liquid or gas under pressure is necessary for high voltage insulation between wires and components. Transferring the heat developed in the equipment to the heat sink via this liquid or gas is a problem requiring much study and careful design. The basic problem is one of forced convection.

In general, subminiaturized electronic equipment with power densities as high as 2 watts per cubic inch can be cooled with liquid. Small liquid-cooled motors of the ac type can be run continuously at over 200 per cent their normal power for their size when air cooled. One liquid-cooled motor pro-

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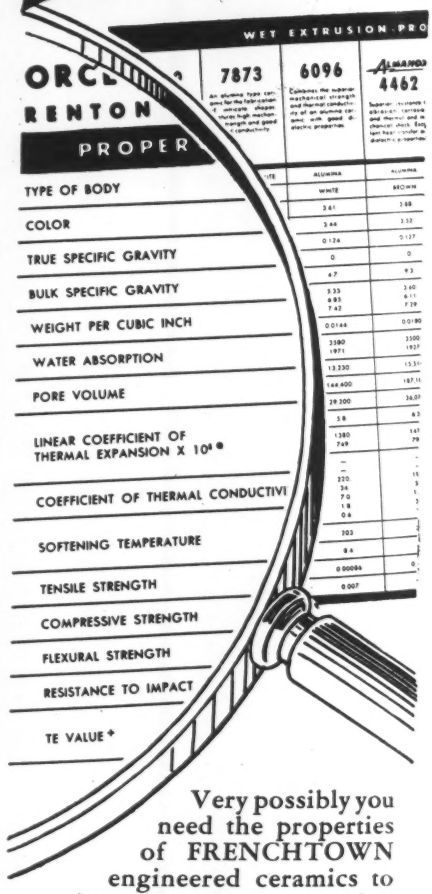

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duced a continuous output of 35 watts while an air-cooled continuously operating motor produced 17 watts and was about 30 per cent larger. A microwave transmitter tube with a dissipation of over 50 watts per square inch has been cooled with a liquid system. In this system, the liquid velocity was purposely kept low to avoid microphonic tube noise. A small centrifugal pump driven by a three-phase, 400-cycle motor drawing 30 volt-amperes was used to circulate the coolant through the tube and associated temperature regulation channels.

The liquid employed in most applications was triethylene glycol. It was chosen because of its high specific heat, high density, low freezing point, and low vapor pressure which permit operation at 50,000 feet altitude without pressurization. This liquid has a high viscosity at low temperatures necessitating a careful consideration of pump design in all respects. In general, pump clearances are made large, fewer guidance vanes are necessary, and high velocities are avoided. As a rule, pumps with 40 to 50 per cent efficiency are possible with this viscous liquid if care is exercised in their design. As a rough rule of thumb, it takes about 5 watts of electrical energy at the pump input for every 100 watts of heat to be removed by the cooling system. This figure may vary twofold depending on the specific cooling requirement.

Future Techniques: In the future, when aircraft speeds progress well past transonic speed, and when altitudes of fifteen miles are commonplace, not only electronic equipment but also hydraulic and rotating electrical machinery will have to be cooled by means other than air. It would appear that fuel would be the best choice for an integrated aircraft, cooling-system heat sink although liquid evaporation will find its place for small isolated pieces of equipment.

From a paper entitled "Cooling Electric Equipment During Supersonic Flight" presented at the SAE National Aeronautic Meeting in Los Angeles, Calif., October, 1953.

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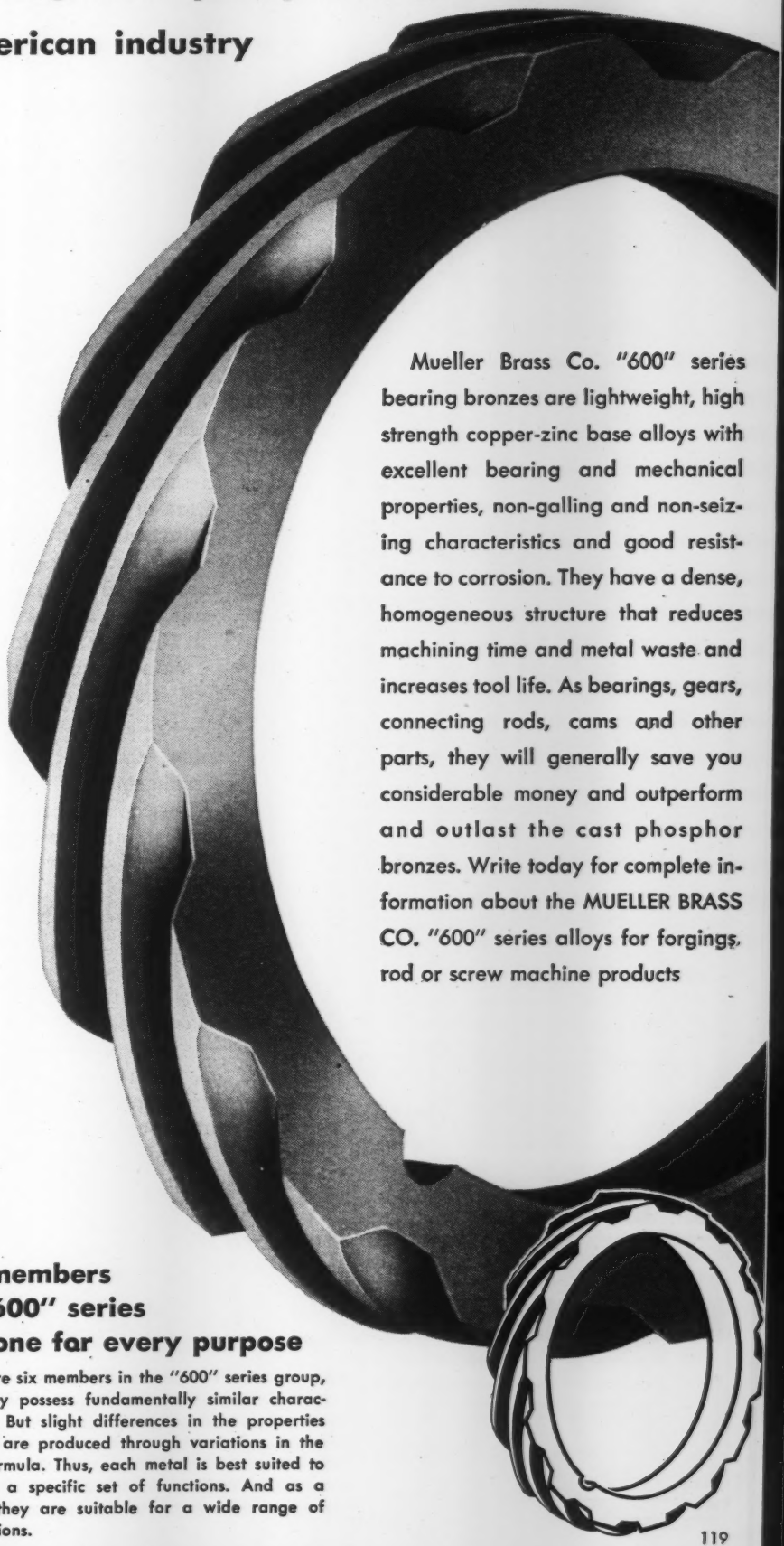

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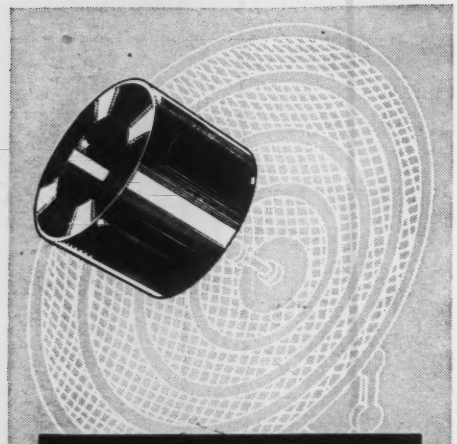

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Television Camera: Has Tele-Vision Transcription "TV-T" shutter for Kinescope recording in the field of industrial television. Television pictures from a receiver tube, occurring at 30 frames per second, can be recorded on 16mm motion picture film at the rate of 24 frames per second without loss of picture quality. Regular live action 16mm sound-on-film talking pictures can be filmed without modifying the camera or changing the shutter. Super 1200 model records continuously for 30 minutes, using 1200-ft film magazines. *Berndt-Bach Inc., Los Angeles, Calif.*

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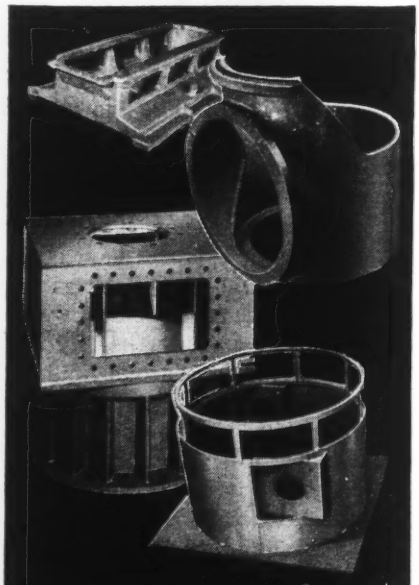

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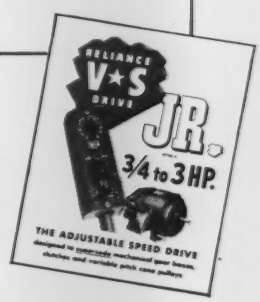

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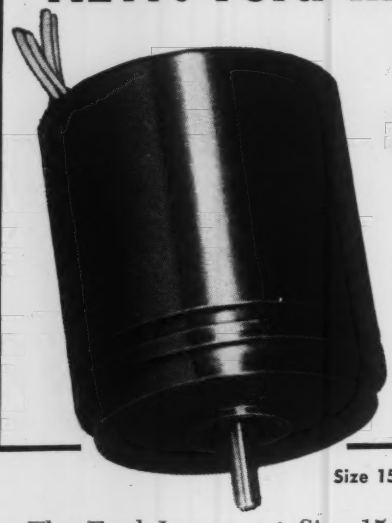

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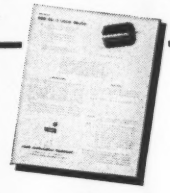

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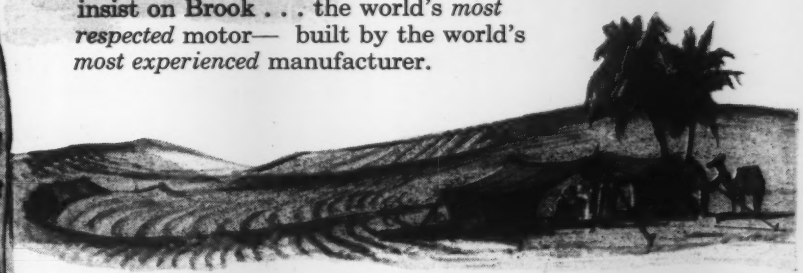

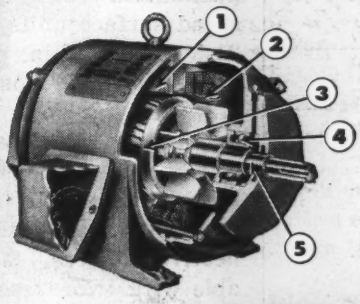

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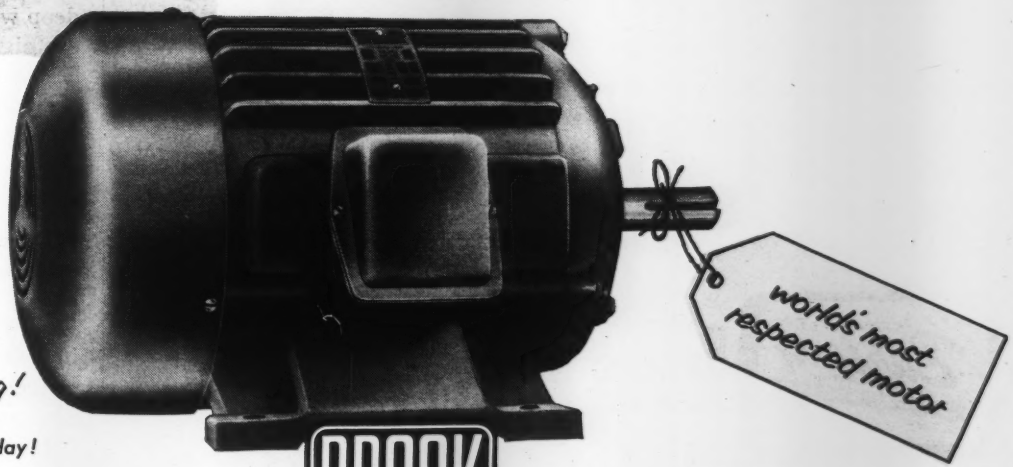

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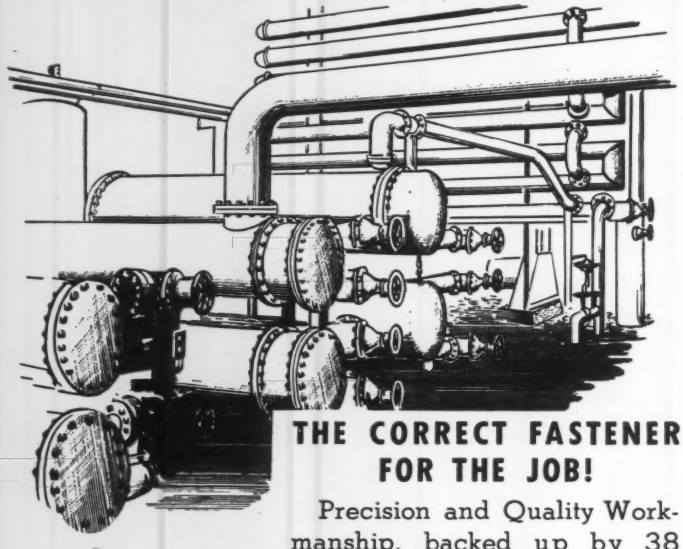

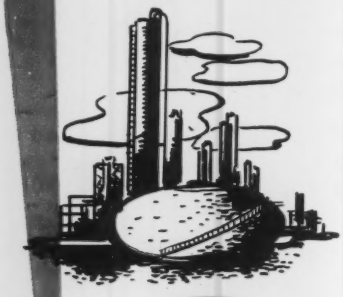

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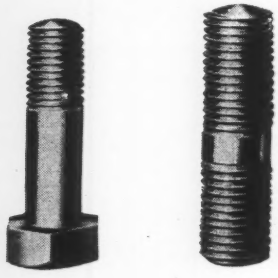

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New Machines

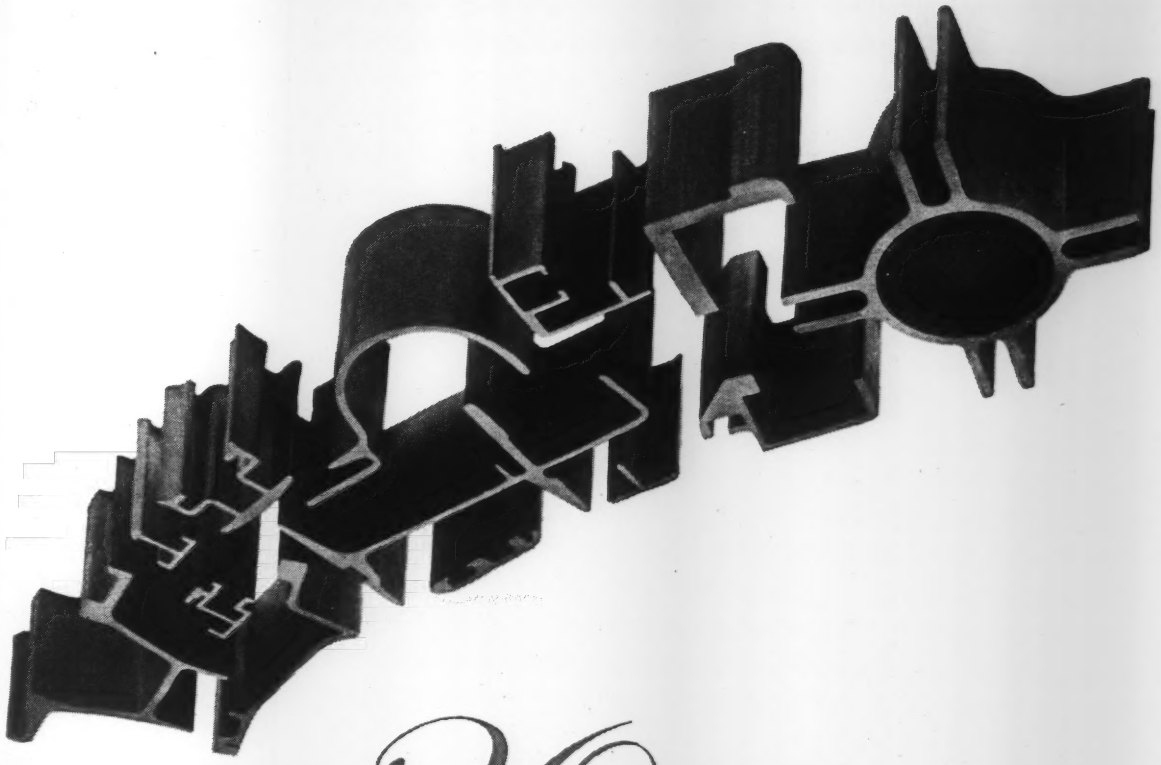
ed cooking tops and switches on the back panel. A nonsliding griddle fits one surface unit and provides a low-heat area sufficiently large for two utensils. Wattage of all six-inch surface heating units has been increased to afford faster heating. *Frigidaire Div., General Motors Corp., Dayton, O.*

Home Freezers: Seven models include 11, 14, and 18-cu ft upright freezers and 13, 17 and 20-cu ft chest units. Upright models have vented shelves which permit cold air to circulate automatically, dry wall construction to eliminate sweating and sub-zero quick freezing shelves. Condensers on all models are located in outer walls to prevent sweating, and condenser coils are installed on the bottom of the chest freezers to prevent collection of moisture. The 11-cu ft upright model, with a capacity of 385 lb of frozen food, has five shelves and an exterior signal light which goes out if the freezer stops operating. *Admiral Corp., Chicago, Ill.*

Electric Ranges: All models have pushbutton controls, extra high-speed surface units, large capacity 21-in. wide, 18-in. deep and 15-in. high ovens, "Focused-heat" broilers and Calrod heating units throughout. Enclosed elements are self-cleaning, and both broil and bake units can be removed to facilitate washing oven walls and reflective surfaces. Models are available with two ovens, an automatic deep well fryer and a warmer drawer; eight standard models in all in 24, 36 and 40-in. sizes. *Major Appliance Div., General Electric Co., Louisville, Ky.*

Heating and Ventilating

Furnaces: Compact horizontal oil-fired model is available with rated output of either 60,000 or 85,000 Btu. "Gravity-plus" furnace provides gravity heat with some characteristics of a forced warm air furnace. Propeller type booster fan provides quick heat response, comparatively low floor to ceiling temperature differentials and good temperature control. A limit switch automatically starts and stops the fan and limits the temperature to



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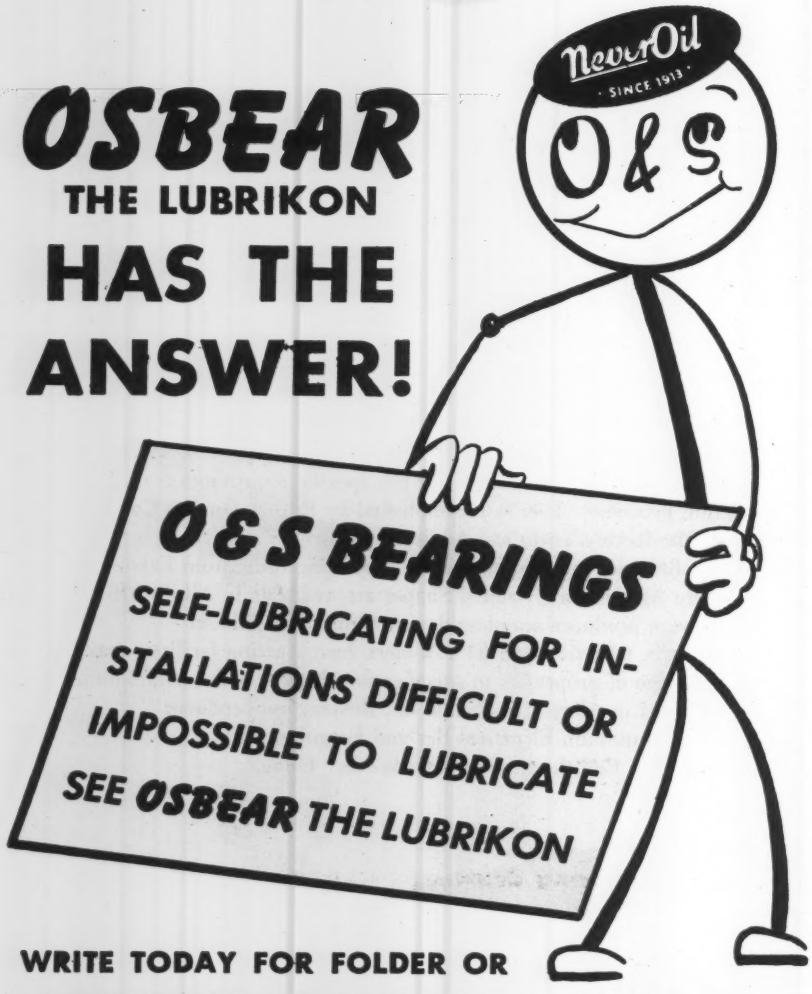

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New Machines

a safe range. Furnace is available with inputs of 60,000, 90,000 and 120,000 Btu. Identification markings for return duct connections are provided on furnaces to facilitate installation. Similar markings for connections to the home cooling unit for integration as a year-round air conditioner are also provided. *General Electric Co., Bloomfield, N. J.*

Air Conditioner: Redesigned package unit is available in 3, 5, 7½, 10 and 15½-ton capacities. Controls permit resetting, without removing panels, if protective relays trip out because of water or power interruption. Horizontal louvers and vertical vanes adjust individually to allow circulation of air in any direction. Accessories include a two-row steam or hot-water heating coil and a spray type humidifier. *Worthington Corp., Harrison, N. J.*

Dehumidifier: Compact unit can also be used as a space heater. It has a 1300-w heater element from which dehumidifier blower drives heat into the room. Water collected from the air is delivered to a flat container that fastens to the back of the dehumidifier. A trap automatically prevents water from dropping while the container is being emptied. *Westinghouse Electric Corp., Pittsburgh, Pa.*

Maintenance

Power Sweeper: Completely motorized; has chain driven brush which is 10 in. in diameter and 36 in. long. Metal hopper with two carrying handles snaps on the front of the brush and can be unsnapped for emptying by one person. Capacity of hopper is 100 lb. Sweeper, used for all types of jobs, will pick up metal shavings. *Eshelman Co., Baltimore, Md.*

Vacuum Machine: Model 215, for heavy-duty dry clean-up work, is powered by a ⅝-hp vacuum motor. Air stream throws dirt against sides of dust container, minimizing clogging of the internal fabric air filter. Mounting on two wheels with semi-pneumatic tires and a rubber-tired caster facilitates handling of the

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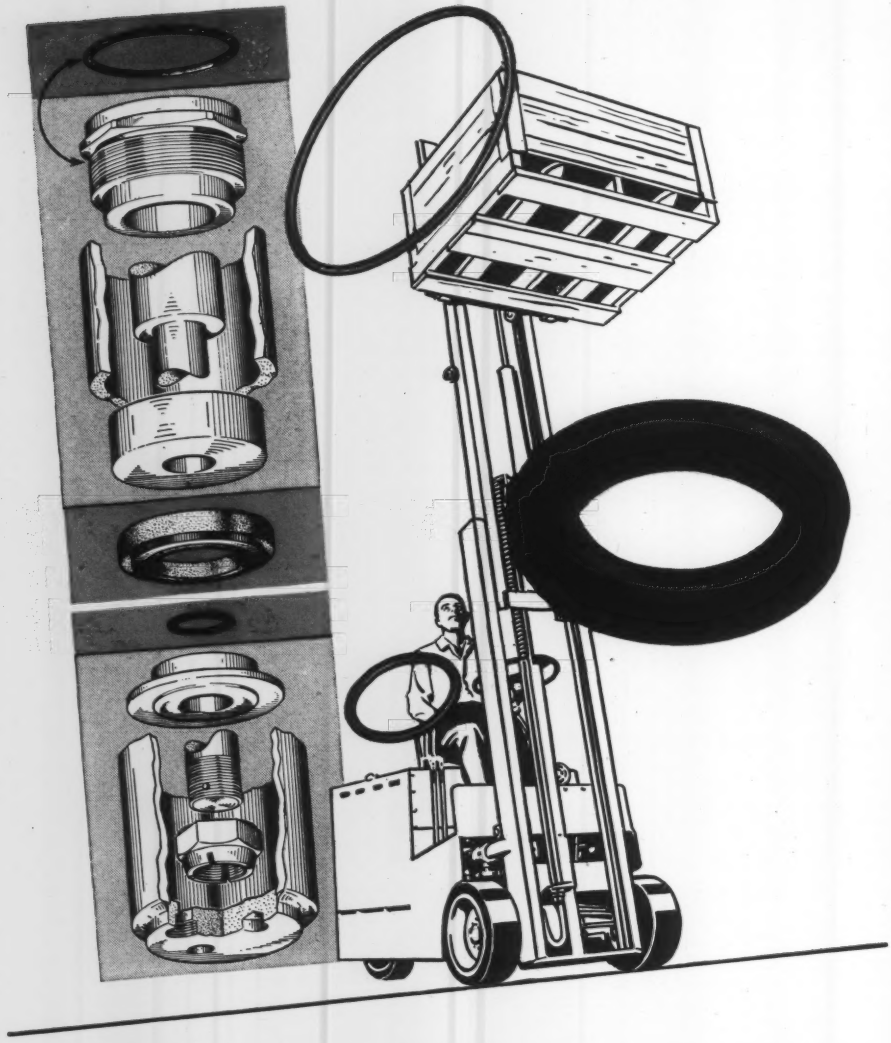

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New Machines

52-lb machine. Floor, wall, ceiling and carpet sweeping tools, as well as a 5-in. utility tool, have swivel connections. Machine may be converted to a blower by switching the 1½-in. diameter hose from the intake connection to the air exhaust outlet. Operates on 115-v ac or dc. *Hild Floor Machine Co. Chicago, Ill.*

Metalworking

Band Saw: Horizontal metal cutting Model 8C cuts 8-in. round stock, 16-in. flat stock, 8-in. pipe and a variety of shapes including very thin sections. Cuts with an accuracy of a few thousandths of an inch with a minimum of kerf and leaves no burr. Saw frame descent through the sawing operation is correctly maintained by a hydraulic mechanism. Cutting action of the saw blade is visible to the operator, and all parts are enclosed. *Machine Tool Div., Kalamazoo Tank and Silo Co., Kalamazoo, Mich.*

Shapers: Type E utility shapers and type ES heavy-duty production shapers are manufactured by Varnamo Maskinaktiebolag, in Sweden. Utility shapers with 14, 18 or 22-in. stroke provide a selection of six ram speeds and four power table feeds. Automatic vertical feed to the tool post is also available on the 18 and 22-in. machines. Heavy production shapers are available with 18, 22 or 26-in. stroke and with plain or universal tables. These machines provide eight ram speeds and ten table feeds through a completely enclosed feed mechanism. A separate motor makes possible rapid power traverse of horizontal table. Has centralized lubrication system. *Austin Industrial Corp., White Plains, N. Y.*

Turret Punch Press: Redesigned hand operated press has a punch indexing control for automatic positioning of die sets. Punches and dies, geared together for permanent alignment, lock in punch position. Turret has 13-in. throat and contains 12 punches and dies that are interchangeable between turret positions. Turrets are geared

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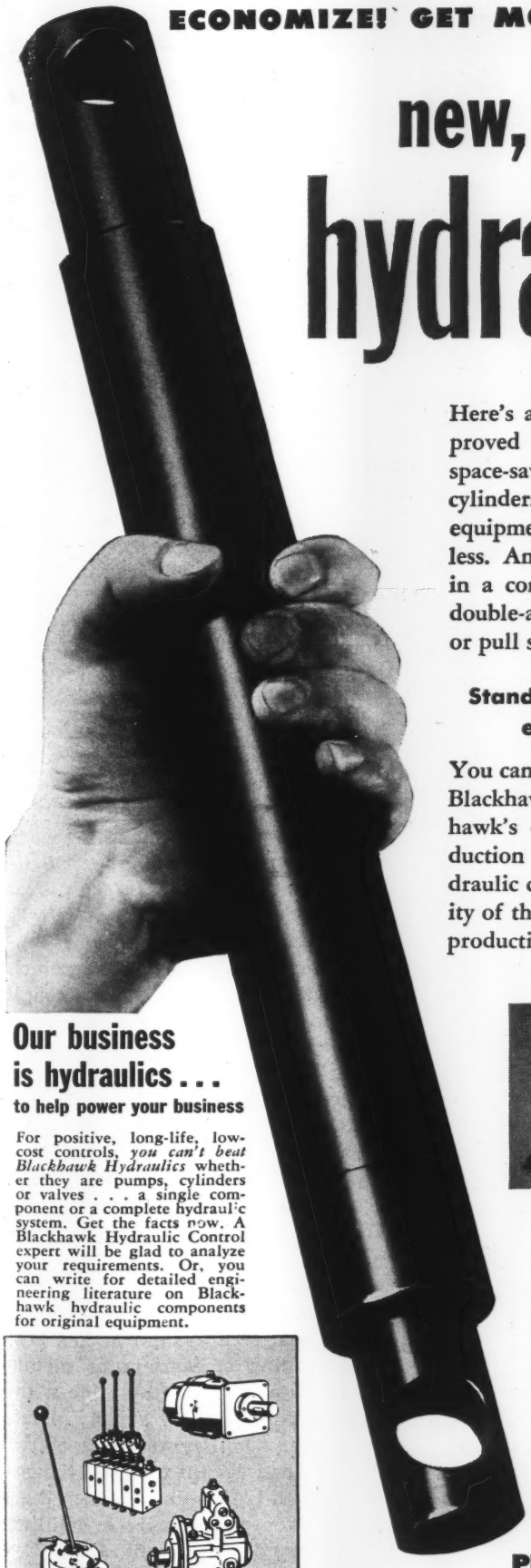
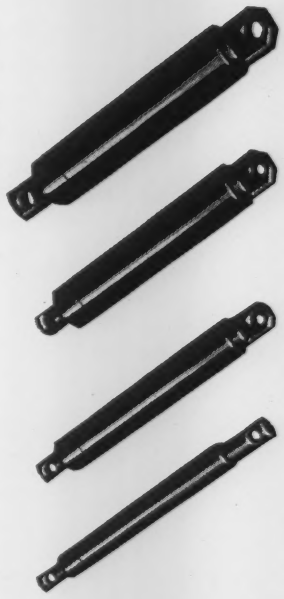
new, all-pressure line of hydraulic cylinders



Here's a dramatic opportunity to build new, improved performance into your products. This space-saving, weight-reducing line of hydraulic cylinders helps you produce more dependable equipment . . . that looks better . . . and costs less. And — Blackhawk cylinders are available in a complete range of sizes, in push and pull double-acting design, or, in models of the push or pull single-acting type.



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You can make attractive savings when you specify Blackhawk cylinders. That's because of Blackhawk's expanded facilities and continuous production of standard cylinders (and other hydraulic components). What's more, high flexibility of the new cylinder design permits economical production of specials on reasonably long runs.

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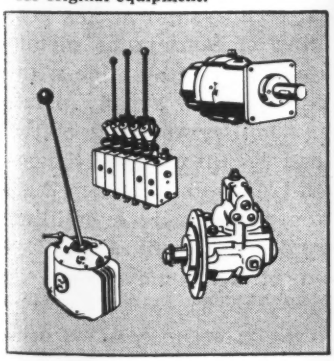
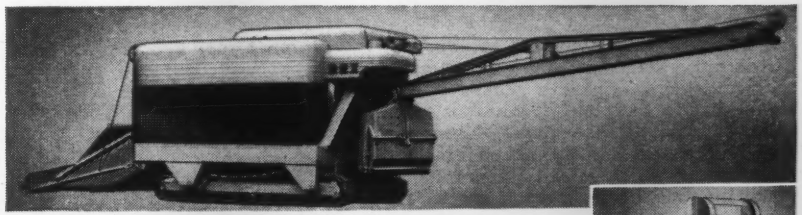
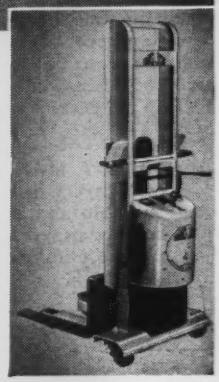
to help power your business

For positive, long-life, low-cost controls, *you can't beat Blackhawk Hydraulics* whether they are pumps, cylinders or valves . . . a single component or a complete hydraulic system. Get the facts now. A Blackhawk Hydraulic Control expert will be glad to analyze your requirements. Or, you can write for detailed engineering literature on Blackhawk hydraulic components for original equipment.





This huge paver features an automatically controlled hydraulic system. The new style Blackhawk cylinders perform an important part in "split-second" control of its mixing and paving cycles.



A Blackhawk "Power-Packer"® self-contained pump, valve and reservoir unit is used on this lift truck.

See Sweet's Product Designer's File.

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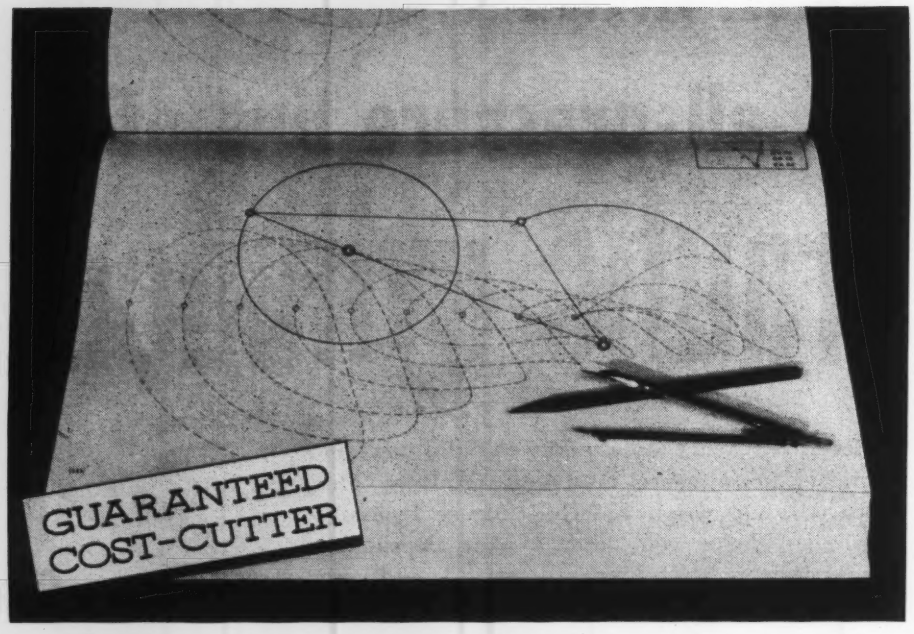

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B-34

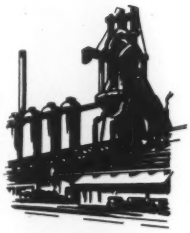
New Machines

together with self-compensating gears to eliminate backlash. Capacity of press is 10 tons; maximum punch size is 1½ in. with ⅛-in. mild steel. Punch diameter is 3/16-in. in ¼-in. steel. *Diamond Machine Tool Co., Pico, Calif.*

Milling-Diesinking Machine: Model 3-DS, manufactured by Taylor, Taylor & Hobson Ltd., England, comprises a high-speed vertical milling spindle coupled to a tracer by a pantograph arrangement. Motion of the cutter follows that of the tracer both horizontally and vertically. Reduction is variable from 1½ to 1 down to 7 to 1. Spindle and tracer are mounted on the pantograph members and may be interchanged to enlarge instead of reduce. Pantograph has ratchet operated feed. Work table and copy table each measure 15 x 8 in. Work table moves 12 x 8 in. horizontally; 9 in. vertically. Copy table moves 6 in. both horizontally and vertically. Vertical motion of tracer is 6 in.; of cutter, 2 in. copying plus 1½ in. feed. Seven spindle speeds range from 800 to 8000 rpm. *British Industries Corp., International Machinery Div., New York, N. Y.*

Lapping Machine: Superior Tru-Finisher produces 3 to 5 microinch finishes. Pieces are first rough ground on a 60 grit silicon carbide wheel at approximately 4 degrees more than the required finish relief and rake angles. Superfinishing is then accomplished by first rough lapping with 600 grit Hyprez diamond compound and then finish lapping with 1800 grit. Diamond wheel grinding is unnecessary. *Garrett Supply Co., Los Angeles, Calif.*

Profile Miller: Co-ordinated tri-directional feed system makes possible milling of nonferrous metals to any profile or contour line without slow-up of feed at any point. Rotary InvOmil power feed of the cutter head is automatically combined with transverse and longitudinal power table feed for milling along any desired profile line. Co-ordination of feed movements is electronically maintained. Template is positioned in setup above workpiece. Cutter head assembly includes a follower. Follower and cutter are held in proper position



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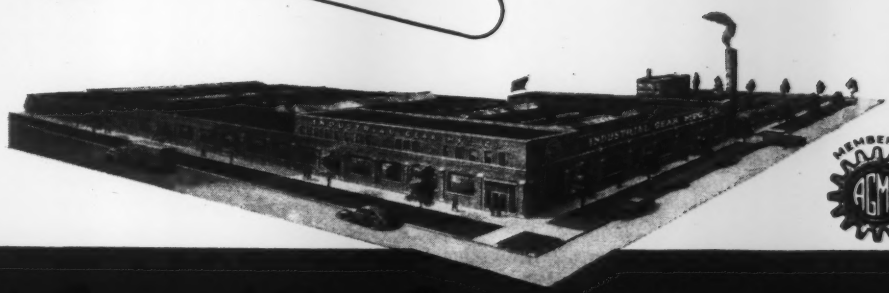

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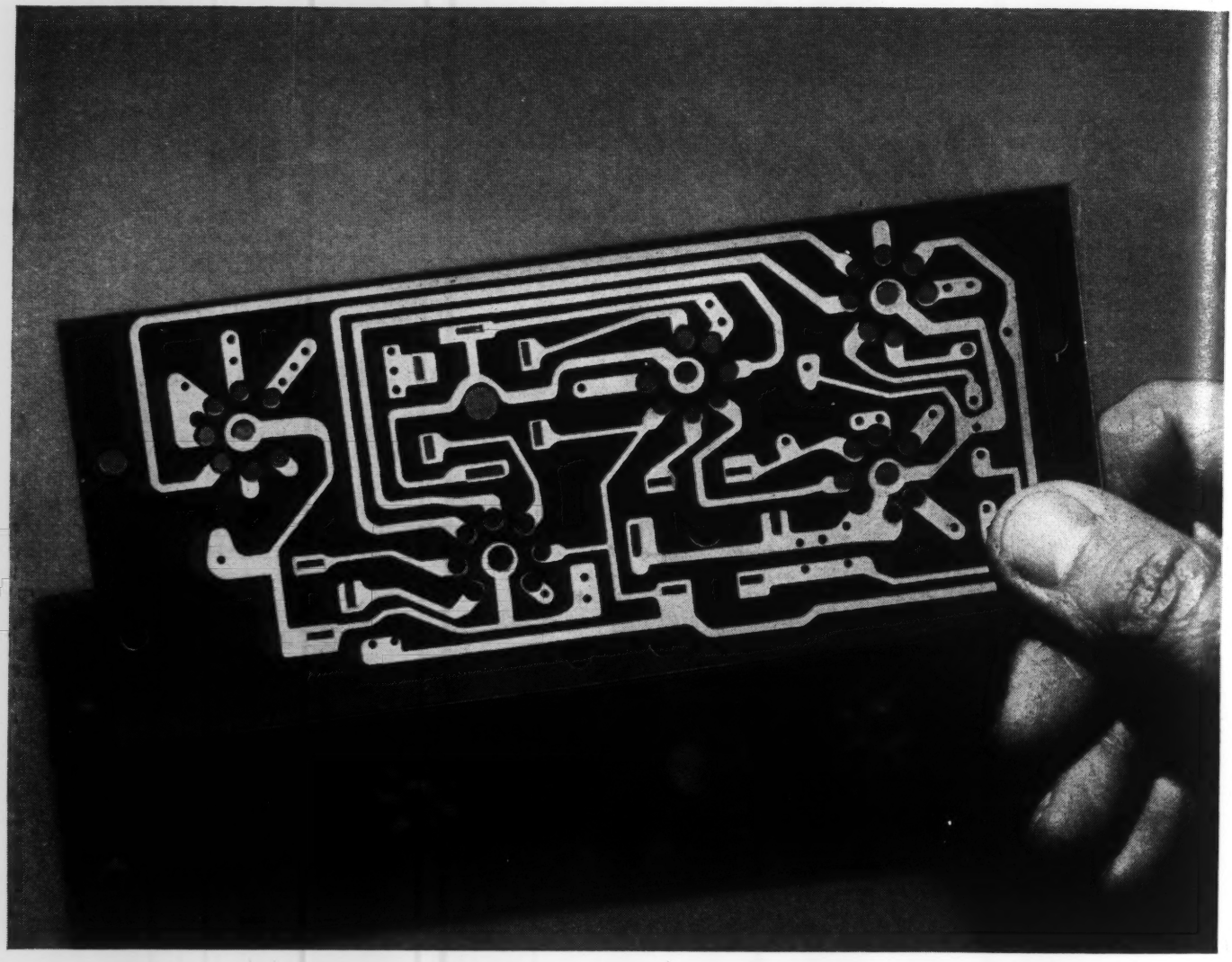
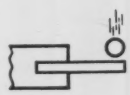
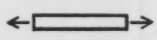


Pattern of things to come

IN ADDITION TO THE PROPERTIES ALREADY MENTIONED IN THE ADVERTISEMENT, SYNTHANE HAS

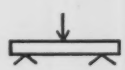


1. Impact strength. Synthane stands up in mechanical applications where jolts, jars and light shock loads are common. It does not splinter or break readily; will not delaminate.

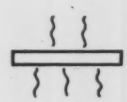


2. Tensile strength. Synthane is strong in tension and compression.

3. Light weight. Synthane has approximately half the weight of aluminum.



4. Flexural strength. Synthane is suitable for jobs where deflexion, torsion and vibration are present. It has excellent fatigue resistance.



5. Stable Over Wide Temperature Range. Synthane is thermosetting; does not flow as temperature rises, has a low coefficient of thermal expansion.

Here is one of the brightest ideas in electronics—and one of the materials which helped make it possible. The idea is the printed circuit; the material is a laminated plastic called *Synthane*.

For years radio sets were put together by laboriously soldering a forest of wires to terminals. It was a time-consuming and expensive operation. If one connection proved faulty, the whole assembly had to be rechecked.

Then someone came up with the idea of *printing* the circuit with an acid-resisting ink on foil bonded to a base—and etching away the metal not needed. It would be quick, easy and error-proof—if the right base material could be found.

Among many tested, *Synthane* was one sheet material selected. Synthane has the necessary strength, low moisture absorption, is an excellent insulator and can be punched easily. It bonds securely to metal foil and withstands the etching acid used to remove the excess metal.

The printed circuit is still in development—but it has zoomed into favor for radio, TV, hearing aids, and many other electronic devices. There are now a dozen ways to produce what are still called "printed" circuits. And Synthane is an accepted base material for every one of them.

Synthane laminated plastics are available in a variety of grades and colors—in sheets, rods, tubes, and fabricated parts. You are invited to write for information to Synthane Corporation, 5 River Road, Oaks, Pa.

SYNTHANE CORPORATION, OAKS, PA.

SYNTHANE
LAMINATED PLASTICS

by a pneumatic pressure device. Stroke of pneumatic cylinder is 4 in.; thus operator has a positioning range of 4 in., along any point of which the follower and cutter will be accurately in position in relation to the template. Vertical direct drive, air cooled, two-speed cutter motor is rated at 15/30 hp at 7200/14,400 rpm. Table size is 27 in. wide and 80 or 98 in. long. Distance from base of chuck to table surface ranges from 0.5 to 18 in. Maximum travel of table in feeds is 12 in. for transverse power feed and 42 in. for longitudinal power feed with 80-in. table; 60 in. with 98-in. table. Machine is also used for straight line milling, and table dogs may be set to control length of table travel in either longitudinal or transverse feed. *Onsrud Machine Works Inc., Chicago, Ill.*

Spring Coiler: Hand-operated machine is used for making prototypes and production runs of up to 1000 compression, extension or torsion springs. Compression springs are coiled to any desired pitch with the coils at both ends squared automatically. Extension springs are wound with or without initial tension, and torsion springs can be wound either left or right-hand with long extended arms on both ends. Machine coils 250 to 400 compression or 200 to 300 extension or torsion springs per hour. Wire diameters can vary from 0.004 to 0.065-in. and spring diameters from 1/32 to 1¼ in., with lengths up to 4½ in. *Carlson Co., New York, N. Y.*

Plant Equipment

Air Compressors: Two-stage compressors are available with either 15 or 20 hp. Displacement is up to 107 cfm of air. Four-cylinder units are available in 22 different models, covering a range of applications. Other specifications are: bore, 5½ × 3 in.; stroke, 5 in.; speed range, 400 to 900 rpm; pressure range, 60 to 200 psi. *Kellogg Div., American Brake Shoe Co., Rochester, N. Y.*

Electronic Smoke Precipitator: Collects oil mist and oil smoke generated from high-speed cutting and grinding operations. Operation is based upon principle of electrostatic attraction. Particles are drawn through ductwork to precipitator and receive a high voltage positive electrical charge. They are then attracted and adhere to collecting plates of negative polarity. Self-cleaning of plates is accomplished by fogging coolant oil directly into the air stream ahead of the precipitator. Collecting plates are kept coated with oil, and the fine smoke particles are collected on a thin film of oil. The smoke deposit and the oil then flow together into a drain pan and back to the machine reservoir. *Trion Inc., McKees Rocks, Pa.*

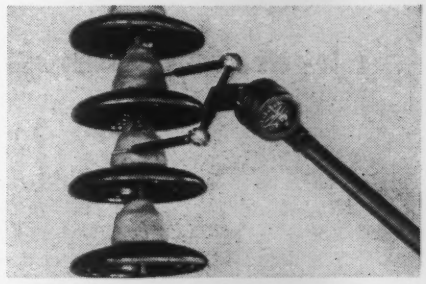
Portable Pump: Model 114, completely self-priming, has no valves or moving parts other than the motor, pump impeller and seal. Delivers over 100 gpm of liquid at lowest head and is capable of forcing water to a maximum height of 100 ft. High suction lift is assured up to and including 25 ft of lift. Has open-faced, nonclogging impeller which fastens directly to the engine shaft. It remains tightly in position by engine rotation but can be removed by unscrewing from the shaft. Wear plate of 3/16-in. thick steel is fastened to pump casing by countersunk head carriage bolts. Intake and discharge connections are tapped for 1½-in. pipe thread. Pump is powered by 1½-hp engine. Complete unit weighs 65 pounds. *Kenco Pump Co., Lorain, O.*

Processing

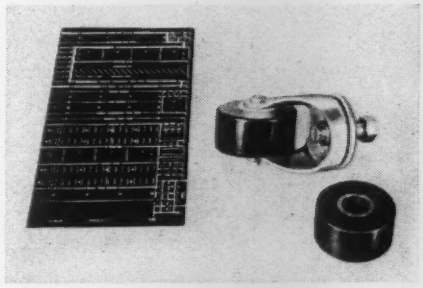
Compression Molding Press: Redesigned semiautomatic toggle type Model 731 molds delicate insert parts such as resistors and capacitors. Has bar controller which gives positive mechanical control over every phase of molding cycle. Calibrated control is provided by means of buttons located on graduated bars. Control settings can be readjusted quickly to meet new requirements when molds are changed and can be reset while the press is in operation. Press has color-coded electrical circuits throughout and seamless steel tubing for all oil lines. Other features include a dustproof control box, fin type coolers with extra capacity to keep oil temperature low and minimize packing and seal failures, a 24 x

SYNTHANE

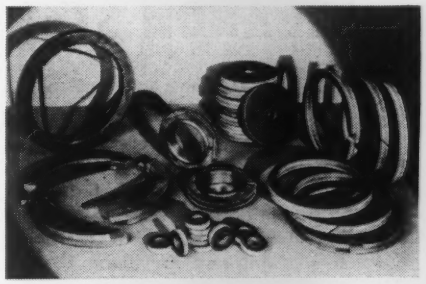
laminated plastics at work



in electrical parts—High dielectric strength of Synthane combined with its light weight is used to advantage in producing high voltage and phase detection equipment.



in business machines—Synthane is valued in the construction of business machines for its light weight, strength, dimensional stability, ease of machining and excellence as an insulator. (Left: plug board for electrically-operated business machine; right: caster wheels.)



in packings—The resistance of Synthane to lube oil, gasoline, moisture, corrosive gases and engine sludge—combined with wear resistance and machineability, makes Synthane desirable for packings of many types, like these by Garlock.

What's your PROBLEM?

MAIL COUPON FOR FREE FOLDER

SYNTHANE CORPORATION
5 River Road, Oaks, Pa.

Please send me your free folder describing advantages, properties, uses, and kinds of Synthane plastics.

My name_____

Title_____

Company_____

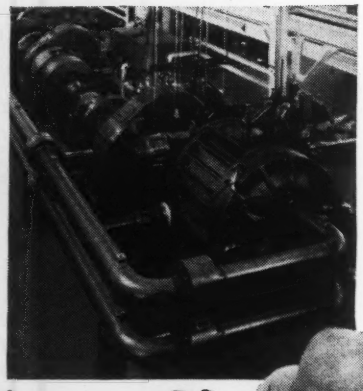
Address_____

City_____ Zone____ State____

in the

World's Largest

oil hydraulic pumps



Upper: Waterbury Size 300 pump under test. Lower: Lebanon casting, machined ready for fabrication.

CIRCLE L

LEBANON STEEL Castings

are at work...

IN WATERBURY TOOL'S SIZE 300 PUMPS—largest oil hydraulic high-pressure pumps ever built—dependable Lebanon CIRCLE Ⓛ castings help confine the tremendous forces developed. These pumps are the working heart of the world's largest tube reducing machine being built by E. W. Bliss Company for Tube Reducing Corporation. On the tube reducer these pumps will move the equivalent of three fully loaded freight cars three feet forward and three feet backward—every two seconds! Each pump weighs 21½ tons, is capable of delivering 2300 gallons per minute at pressures up to 3000 p.s.i. and can transmit up to 4000 H.P.

Lebanon steel castings in the pumps for this extraordinary machine that cold rolls tubing up to 18" O.D., were engineered and built for enduring service.

● See—STEEL WITH A THOUSAND QUALITIES—37-min., 16 mm, semi-technical, full-color, sound film on the making of steel castings. For information write: Dept. G, Lebanon Steel Foundry.

LEBANON Castings

CARBON, SPECIAL ALLOY AND STAINLESS STEEL

CIRCLE L

LEBANON STEEL FOUNDRY LEBANON, PA.

New Machines

24-in. platen area and a wide spacing between tie rods (front to back) to provide stability and to accommodate a wide range of knockout actions. Three-stage automatically controlled closing action reduces closing time and speeds up production cycle. Mold closes only as fast as the material plasticizes. *F. J. Stokes Machine Co., Philadelphia, Pa.*

Vertical-Flow Cabinet Oven: Low heat loss is claimed, accomplished by use of double gasketed doors with heat trap, high-low selective heat intensity control and absence of metal-to-metal contact. Insulation is 5 in. of glass fiber. High-pressure motor driven blower propels heated air in a definite air flow pattern through the work chamber. Equipped with an accurate indicating temperature control, a manual interlock for either rapid cooling or purge period operation of blower without heat, adjustable positive exhaust and intake, and belt driven fans. Made in two sizes with work space 26 x 26 x 38 in. high and 26 x 38 x 50 in. high. Heats to temperatures of 650 or 850 F. *Grieve-Hendry Co. Inc., Chicago, Ill.*

Chilling Machine: Chills ball and roller bearings for stabilization. Factory adjusted for operation at −120 F, unit can be operated as cold as −150 F. Capacity is 22 cu ft; thermal capacity is 4000 Btu per hour. Parts are loaded from oil quench into a basket which is placed in the chilling chamber. This chamber is filled with Freon 11. Twin-blade agitator mounted in the corner of the chamber drives fluid down a draft tube, through a manifold and up through the basket of parts. This method permits cooling of 170 lb of steel an hour from 80 to −120 F. Chamber is 38 in. long, 32 in. wide and 36 in. deep. Outside dimensions of unit are 84 in. long, 61 in. wide, 50 in. high. *Sub-Zero Products Co., Cincinnati, O.*

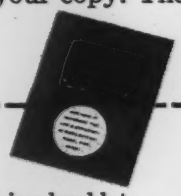
Surface Finishing Machine: Model 207 shouldering machine performs necking operations on spoons, shouldering operations on knife blade bolsters and similar operations. Full 38-in. work racks can be transferred from other Clair

The Problem: Serious friction problems were preventing the acceptance of a unit manufactured by a nationally known producer of aircraft equipment. Electrofilming, chrome plating and other excellent surface treatments were tested without success. The treatments that reduced friction appreciably failed to meet the corrosion specification. Those that provided the required corrosion resistance failed to reduce friction within the required limits.

How it was solved: Following a meeting held with the engineers responsible for the project, ELECTROLIZED parts were tested. Friction was reduced by 50% and the 100-hour salt spray requirement was met. Repetitive tests established the consistency of ELECTROLIZING to the satisfaction of the authority responsible for the acceptance of the unit. ELECTROLIZING was incorporated in the drawing.

What it means to you: If you are searching for an answer to friction, wear, abrasion, or corrosion problems, ELECTROLIZING is the ideal starting point.

At no cost and without sacrificing project time, you can quickly appraise this process in terms of your own needs. Our 16-page booklet will help you. It describes some of the difficult engineering problems that have been solved with ELECTROLIZING. Just return the coupon for your copy. There is no obligation.



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1505 East End Avenue
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Please send me the 16-page Electrolizing booklet:

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(Please Print)

Company .....

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surface finishing machines for the application of a 90-degree angle cross buff, providing coverage on both sides of the pieces in many otherwise inaccessible radii and angles. Two 3-hp, 1800 rpm, totally enclosed dustproof motors provide buff speeds to 3600 rpm. Horizontal stroke of work racks, through and clear of buffs is adjustable from 0 to 44 in. Independent lever adjustment permits lowering or raising of either of the two buffs through a 1-in. range. Uniform floating contact between buffs and work at any predetermined setting of an automatic pressure regulator is provided by a roll pressure control air cylinder which also actuates the buff arbors from open to closed position. Independent hand crank adjustments permit individual tilting of buff arbors through 12½-degree arcs. *Clair Mfg. Co., Olean, N. Y.*

Low-Pressure Press: For molding reinforced plastics; utilizes air cylinder pressure for 90 per cent of platen or die travel. Self-contained hydraulic unit furnishes power for pressure stroke. Installation requires only air line connections and electricity for control units. Stroke, daylight openings and pressures can be furnished in various combinations. *Davidson-Kennedy Co., Atlanta, Ga.*

Induction Heater: Designed for soft soldering and silver brazing, model 5000 RF heater permits very high no-load circulating currents in the work coil. It uses single turn or half turn work coils which can be touched by the operator or work during operation. Has air cooled 10 kw oscillator tube. Work coil, located at table top height, requires 1/3 gpm of cooling water. Rated capacity is full 5 kw output. Floor space required is 18 x 26 in. *Radio Frequency Co., Medfield, Mass.*

Testing and Inspection

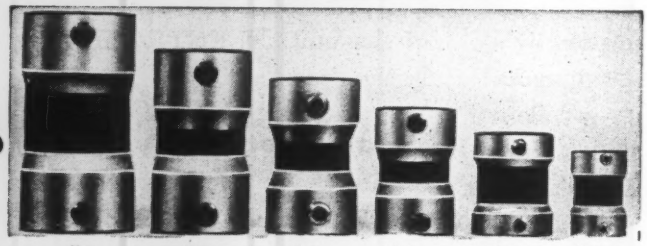
Air Gage: Consisting of three air spindles and a five-column Precisionaire unit, gage permits inspection of five dimensions on an oil pump body. Spindle with a Balljet at the top checks depth and parallelism of the inside surface of the pump body. Depth is indicated by the float position in the Precisionaire column; parallelism by the float variation as the part is moved around the spindle. Remaining two air spindles gage bore diameter, radius, and concentricity of the bore with the radius. Single jet in the large diameter of the spindle checks radius and is also used in conjunction with a jet in the smaller diameter for checking concentricity as the part is rotated. A set of jets in the smaller diameter is used to check bore size. *Sheffield Corp., Dayton, O.*

Brinell Hardness Tester: Model KDR-10X fits directly into conveyor system. A roller conveyor is arranged in conjuction with the anvil of the tester, the anvil itself consisting of a series of hardened steel bars affixed to the lower portion of the machine's C-frame. Between these bars are the conveyor rollers which are lowered and raised automatically during the testing cycle. Machine is motor driven, hydraulically operated. Dial indicates depth of impression and has two hands which show hard and soft limits. *Steel City Testing Machines Inc., Detroit, Mich.*

Gear Tester: Model 1136 Sine-Line involute checker handles large spur or helical gears up to 36-in. pitch diameter and with a maximum spread between centers of 26 in.; also checks tooth spacing. Single master disk, combined with a sine bar, provides proper ratio between master disk and base diameter of gear being checked. Involute profile is checked by first setting sine bar and indicator contact point in correct relation to base diameter of gear. Movement of sine-bar table transmits movement of indicator contact point tangential to base circle of gear. Simultaneous rotation of gear causes indicator contact to trace a true involute. Drive is positive through a steel tape. Removable bracket attached to indicator head holds fingers for checking tooth spacing. Helical gears can be checked in either normal or transverse plane. Internal gears can be checked by replacing the contact point with an L-shaped extension supporting a contact point in reverse radial position to that of the usual type. *Michigan Tool Co., Detroit, Mich.*

"TO TRANSMIT NOISELESSLY..."

HERE...



#4 #3 #2 #1 #0 #00

specify Guardian FLEXIBLE COUPLINGS

Guardian "Dyna-Line" flexible couplings are solving drive problems in a wide variety of applications. Typical of these, with our No. 00-R from instrumentation to light pump and accessory drives, is the case history at the right.

The flex-element length, duro, compound and reinforcement all function to provide required flexibility and dampening. One-piece design means freedom from noise, lubrication and friction-drag, particularly in minor misalignment.

Our product application dept. will welcome consideration of your drive problem.

FROM OUR PRODUCT APPLICATION FILE

Case History No. 22—00

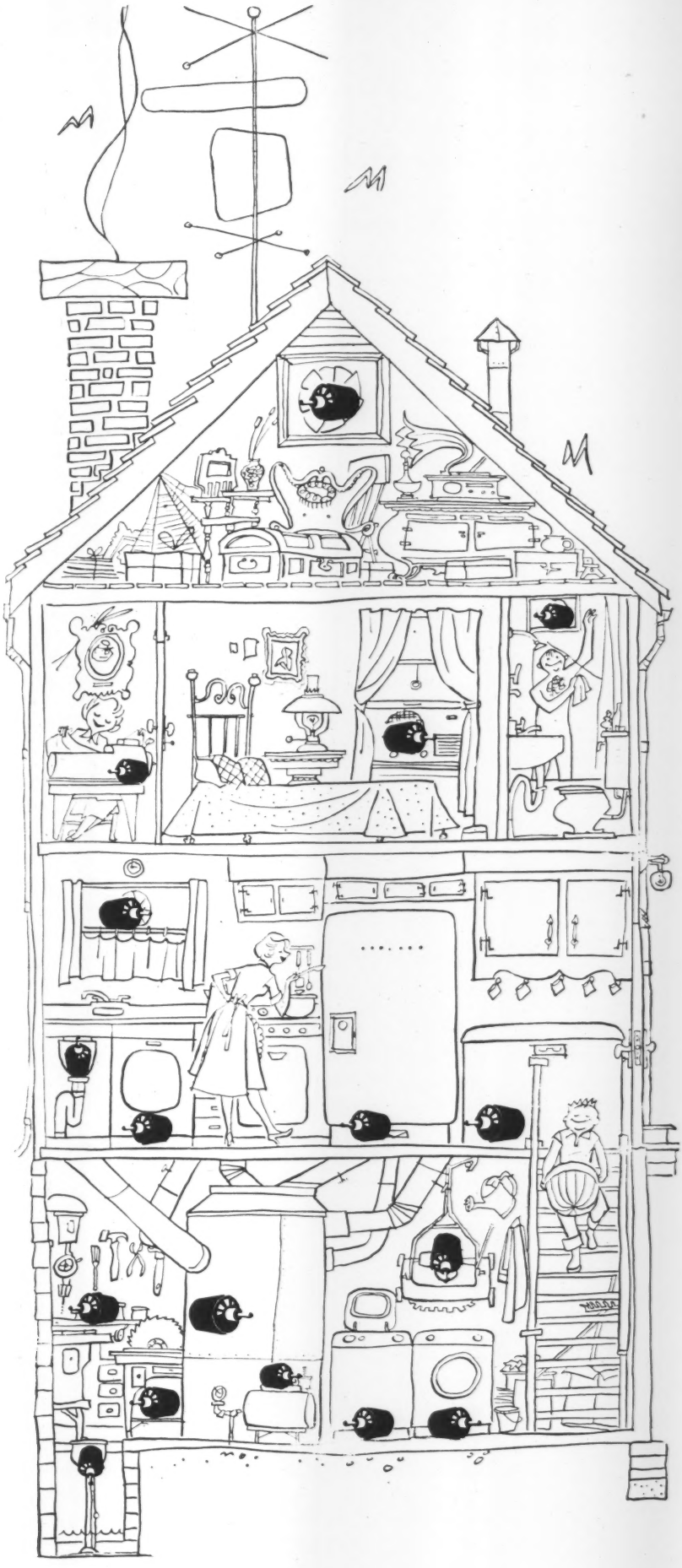
PROBLEM—A nationally advertised sewing machine required coupling *to transmit noiselessly* the 60 watt 6000 rpm of a cushion-mounted motor. The coupling must absorb misalignment to 1/16", yet provide steady power transmission without whip or backlash.

SOLUTION—Guardian Dyna-Line No. 00-R 2.25" long with standard Flex-Elements met all requirements. Length specified carried no "special length price".

Write for Catalog Page C102 and Drive Data Form #53.

Guardian PRODUCTS CORP.
COUPLING DIVISION
Dept. IC-M, 1215 E. Second St., Michigan City, Ind.

Guardian
QUALITY IS TRUE ECONOMY



DELCO MOTORS

the best running mate your product can have

There are millions of Delco motors —fractionals and integrals—now serving reliably to operate appliances, tools, machinery and equipment of every sort.

Such universal approval suggests that a Delco motor gives a good account of itself, performance-wise. Such universal approval suggests, too, that a Delco motor would make the best running mate for *your* product!

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DIVISION OF
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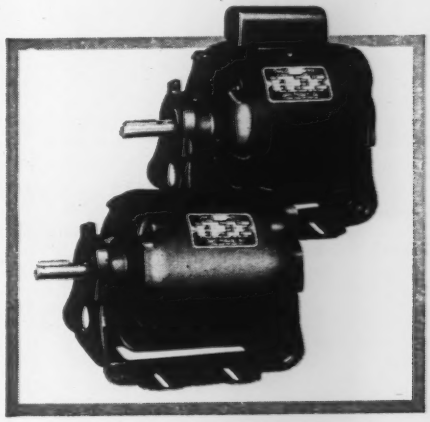


REID

TOOL ROOM ACCESSORIES

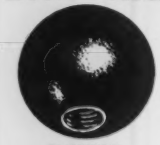
CAST IRON HAND WHEELS

COUNTER BALANCED

SOLID WEB

Best quality. Straight and dished. Both spoke and solid web types. Rims polished to high lustre with or without solid or revolving handles.

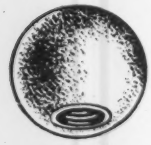
BALL HANDLES-THREADED



ROUND PLASTIC

OA OVAL PLASTIC

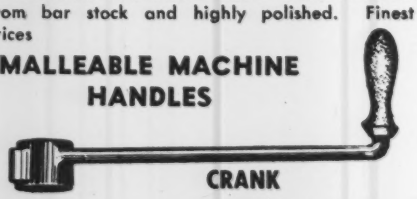
MUSHROOM PLASTIC



ROUND STEEL

Give product that "dressed up" appearance. Made in a wide variety of diameters and thread sizes. Steel ball handles are turned from bar stock and highly polished. Finest quality at low prices

MALLEABLE MACHINE HANDLES



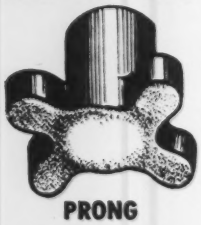
CRANK

STRAIGHT

Crank, straight and offset types in wide variety of sizes. Smooth finish. Low prices.

CAST IRON HAND KNOBS

LONG SHANK



PRONG

Three types: Long shank with wrench hex., Scalloped and Prong. Many sizes. Made of fine grain cast iron. Smooth finish. No sharp edges. Low prices

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REID TOOL SUPPLY CO.
Muskegon Heights, Mich.
Gentlemen:
Please send me FREE 48 page catalog, illustrating and describing the REID line of necessary and hard-to-get components and accessories.
Name .....
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MEN OF MACHINES

William Littlewood

William Littlewood, engineering vice president of American Airlines Inc., will serve as president of the Society of Automotive Engineers for 1954. Mr. Littlewood received a mechanical engineering degree from Cornell University in 1920, served as an engineer with Niles-Bement-Pond and Ingersoll Rand, then joined Fairchild Engine & Airplane Co. as production manager in 1927. He was soon named general manager and was given responsibility for developing the first Ranger aircraft engine. He joined American Airways Inc. in 1930, was made chief engineer three years later, and was appointed to his present position soon after the firm became American Airlines Inc. in 1934. He has gained recognition for his part in the development of such transport planes as the Convair 240 and the Douglas DC series.

An SAE member since 1936, Mr. Littlewood was the first vice president of the society's Air Transport Activity. He has served on numerous SAE aeronautical engineering committees and was awarded the Wright Brothers Medal in 1935 for presentation of the year's outstanding technical paper on aeronautical engineering.

♦

George D. Hooper has joined the Carboloy department of General Electric Co., Detroit, as a development engineer in the magnet materials and process development unit. He was formerly chief engineer and plant manager of National Machine & Tool Co.

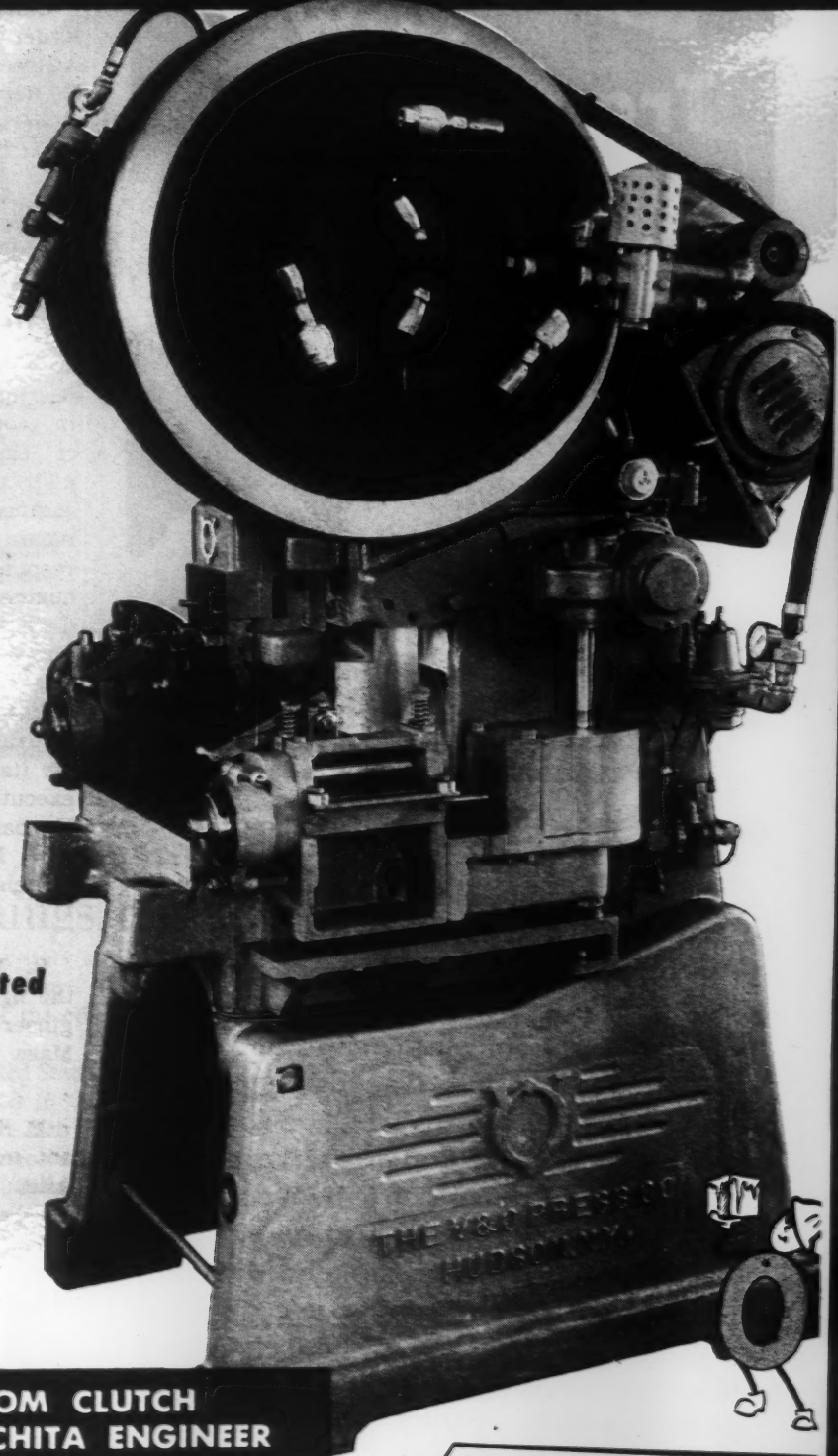
♦

A. M. Harrison and **P. G. Lessmann** have been named manager and assistant manager, respectively, of the transportation and generator engineering department of Westinghouse Electric Corp., East Pittsburgh, Pa.

The company also recently announced two ap-

Wichita...the Answer to

CLUTCH PROBLEMS for HIGH SPEED OPERATIONS!



To have perfect control on high speed presses operating at 450 Strokes Per Minute, clutches must disengage very quickly, because the elapsed time is extremely short between the ram at the bottom and at the top center. This is a major requirement on 45 ton V & O High Speed Presses. Because Wichita 18" Low Inertia Clutches are the answer to this and many other press clutch problems . . . **WICHITA CLUTCHES WERE SELECTED.**

In addition, the extremely fast action, of Wichita Clutches and Brakes, is ideal for inching (or jogging) and single stroke operation.

The Wichita Clutch on the press pictured here has been operated in excess of 100 engagements per minute **WITHOUT DEVELOPING ANY TROUBLE . . . HEAT INCLUDED!**

WICHITA Low Inertia, Positively Ventilated CLUTCHES Will Eliminate:

- **Heat Problems**
- **Adjustment Problems**
- **Lubrication Problems**
- **Centrifugal Force Problems**
- **Self Energization Problems**

TO GAIN MAXIMUM EFFICIENCY FROM CLUTCH OPERATION SEE YOUR NEAREST WICHITA ENGINEER

WICHITA DISTRIBUTORS

Brehm-Lohner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., (Main Office) West Hartford, Conn.
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WICHITA Falls
WICHITA FALLS, TEXAS U.S.A.

Ad—

Smooth... Power Transmission

LOVEJOY

FLEXIBLE COUPLINGS

MODERN DESIGNers specify Lovejoy Flexible Couplings because they offer the best obtainable insurance against alignment troubles—dampen and absorb starting torque, vibration and shock of intermittent loads . . . protect motor and driven machine . . . lengthen bearing life. Lovejoy Flexible Couplings are rugged in construction, provide excellent resiliency. Bodies are carefully machined. Cushions are available in materials suited to the particular load conditions . . . can be changed without shutdown. No lubrication is needed.

WRITE TODAY FOR FREE ILLUSTRATED CATALOG WITH HANDY SELECTOR CHARTS. →

Also Mfrs. of Lovejoy Universal Joints and Lovejoy Variable Speed Pulleys

LOVEJOY FLEXIBLE COUPLING CO.

4818 W. Lake Street • Chicago, Illinois

Men of Machines

pointments in the new engineering and service department of its Apparatus Div. **Maynard B. Wyman** is department manager, and **H. C. Coleman** is assistant manager.

♦

Chief engineer since January 1953, **Edmund L. Ryder** was recently appointed assistant manager of AiResearch Aviation Service Co., Los Angeles. **Frank R. Berry Jr.**, former project engineer, succeeds Mr. Ryder as chief engineer.

♦

Fred W. Gottschling

Greer Hydraulics Inc., Brooklyn, N. Y., has announced the appointment of **Fred W. Gottschling** as director of engineering. He will be in complete charge of the function of all the company's engineering departments and will be responsible to chief engineer and president **Edward M. Greer.** Mr. Gottschling first became associated with Greer Hydraulics soon after its founding 11 years ago and has served in an executive position in the engineering department. He has also been associated with Hydreco of Cleveland, Parker Aircraft and Marman Products of Los Angeles.

♦

R. M. Swetland has been appointed manager of the lighting and rectifier department illuminating engineering laboratory of General Electric Co. at Lynn, Mass.

♦

P. S. Christaldi was recently promoted from assistant manager to manager of the Instrument Div. of Allen B. Du Mont Laboratories Inc. Dr. Christaldi has been associated with Du Mont since 1938.

♦

Avco Mfg. Corp., Cincinnati, has appointed former assistant director of engineering **Donald M. Strathearn** to the position of director of engineering. He will direct the laundry engineering department at South Bend, Ind.

♦

Fielden Instrument Div. of Robertshaw-Fulton Controls Co., Philadelphia, has appointed **Frederick L. Maltby** as technical director in charge of all research, development and design facilities. Previously, Mr. Maltby was associated with the Bristol Co.

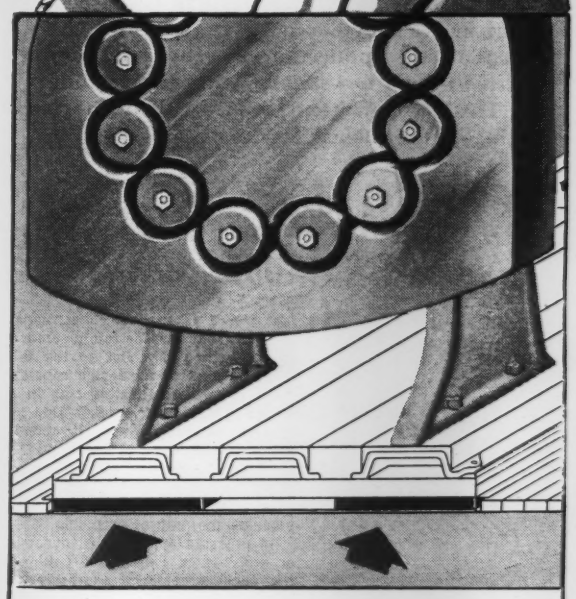
The office workers had the shakes...

but U.S. Sturdicell smoothed things out

When fourteen machines were installed in a four-story structural steel frame building in New Jersey, havoc broke loose. The machines caused so much noise and vibration that the office force on another floor found work unbearable.

Someone made a wise move and called in United States Rubber Company engineers. The "U.S." men proceeded to "float" the machines on U.S. Sturdicell rubber slabs, only one inch thick. The slabs were cut to the required width right on the job site with an ordinary knife. The result? Things not only quieted down in a hurry, but the machines now have extra protection against shock and impact loads, resulting in reduced maintenance costs.

Make a practice of consulting "U.S." on problems of this kind. We also manufacture a complete line of rubber-to-metal mountings. For complete information, call any of our 25 District Sales Offices, each staffed with engineers, or write address below.



Arrows indicate location of U.S. Sturdicell slabs that cushion machine.

"U.S." Research perfects it
"U.S." Production builds it
U.S. Industry depends on it

US RUBBER

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Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes
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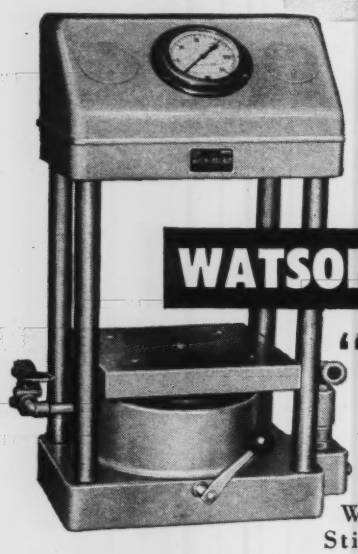
PALMETTO®
G-T®
RING

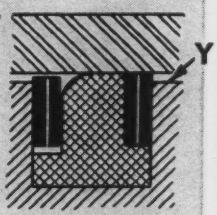


Perfect for the
WATSON-STILLMAN
"Lab" Press

Widely used Watson-Stillman Laboratory Presses, with capacities from 10 to 100 tons, operate at a maximum pressure of 6,050 psi. Conventional packings, because of extrusion had to be replaced in 4 to 7 days; the G-T Ring, in the same application—as a dynamic ram seal—lasted from 3 to 4 months without extruding!

That's why Watson-Stillman switched to the G-T Ring—and switched for good!

CANNOT EXTRUDE, *because*



As pressure is applied, conventional packings soon extrude into clearance space Y, then fail. Not so the G-T Ring! Because of its design consisting of a resilient sealing ring in a T-Section supported on each side by two non-extrusion rings, it cannot extrude. As pressure is applied to the G-T Ring, the resilient material flows under the non-extrusion rings, urging them against the cylinder wall and blocking the path of extrusion.

In pressure applications, dynamic or static—pick Palmetto G-T Ring—the packing designed expressly for non-extrusion.

Write for our Manual MP-200, Engineering Standards for Palmetto Molded Packings. For design information on G-T Rings, see our catalog in Sweet's Product Design File.

PALMETTO Packings

packing more performance into every application

GREENE, TWEED & CO. North Wales, Pa.

Men of Machines

and the Rudolph Wurlitzer Co. and also taught at the University of Buffalo.

The Fielden Instrument Div. also recently appointed **Lee E. Cuckler** as manager of its engineering department.

♦

George O. Bohrer has been named chief engineer of Magnesium Co. of America, East Chicago, Ind., and **C. Ridgely Kemp** was appointed to the newly created position of vice president in charge of research and development.

♦

New director of engineering of Mine Safety Appliances Co., Pittsburgh, is **Charles W. Punton,** who joined the company in 1929.

♦

Marshall Holt

Marshall Holt was recently elected national president of the Society for Experimental Stress Analysis. Dr. Holt joined the aluminum research laboratories of the Aluminum Co. of America at New Kensington, Pa., in 1929 and has been assistant chief of the engineering design division since 1951. He received his bachelor of science degree from the University of Illinois in 1927 and was awarded the master of science degree two years later. While completing his master's degree, Dr. Holt was a graduate assistant in the Engineering Experiment Station of the University of Illinois. Work at both Carnegie Institute of Technology and the University of Pittsburgh led to his receiving the Ph.D. degree from the latter school in 1947 with a major in engineering mathemathics.

♦

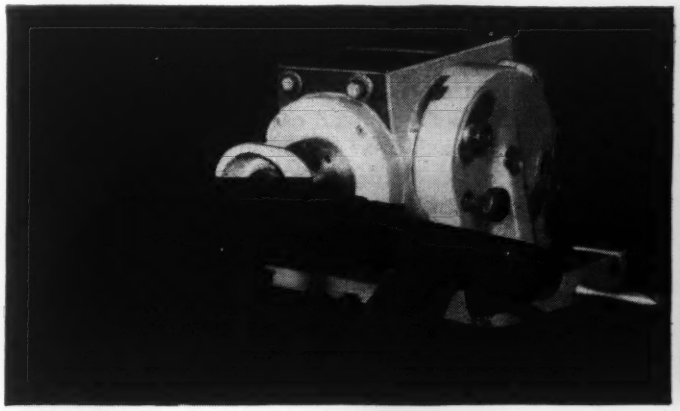
William Few has been appointed chief engineer of Penn Controls Inc., Goshen, Ind. Mr. Few will be responsible for the company's expanded research and development program. Formerly manager of the electronic and allied products division of Clark Controller Co., he was also once associated with General Electric.

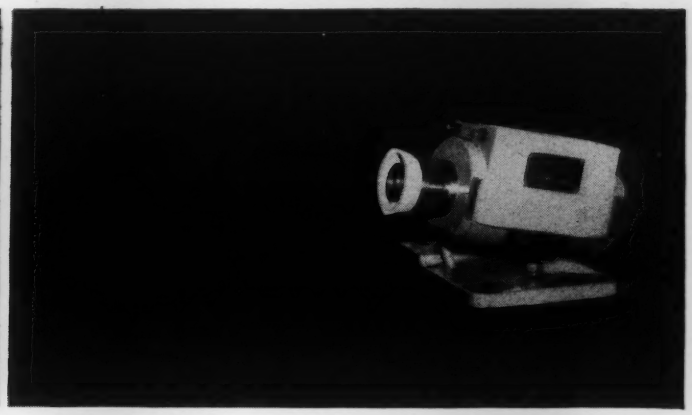
♦

A special projects group has been organized within the engineering staff of Ford Motor Co., Dearborn, Mich., for research in advanced body design. The group will be headed by **J. C. Widman** as body engineer for special projects and will operate as a staff function directly under **H. C. Grebe,** executive body engineer. Replacing Mr. Widman as body engineer on

Specify THIS NEW **POPE** SUPER PRECISION
1 HP, 3600 RPM MOTORIZED TOOL AND CUTTER GRINDER
CLEARANCE ANGLE SWIVELLING HEAD

With Angular Adjustment In A Vertical Plane





TIME AND MONEY SAVING FEATURES:

1. Cup wheels, generally considered best for cutter grinding, can be used for practically all clearance angles on this new head.
2. Cup wheels produce a cutting edge on tools that lasts longer because it is stronger.
3. The tooth rest remains on the center line of the cutter for practically all grinding on centers or in the work head.
4. Most cutters and reamers can be ground all over with *one* set-up, using the swivelling table and Pope tilting head. The usual second and third set-ups are no longer required.
5. All clearance angles read directly in degrees from the scale provided on the head. Mistakes on clearance angles are avoided.
6. The right clearance angle is assured on tools difficult to grind, such as slab mills, taper reamers, angular cutters and form tools.
7. 3600 R.P.M. — one wheel speed — safe for all wheels generally used on cutter grinders. Heat checking of cutters is virtually eliminated.
8. The operating ease and convenience of this new Pope Head with the angular adjustment in the vertical plane saves you time and money on every tool you grind.

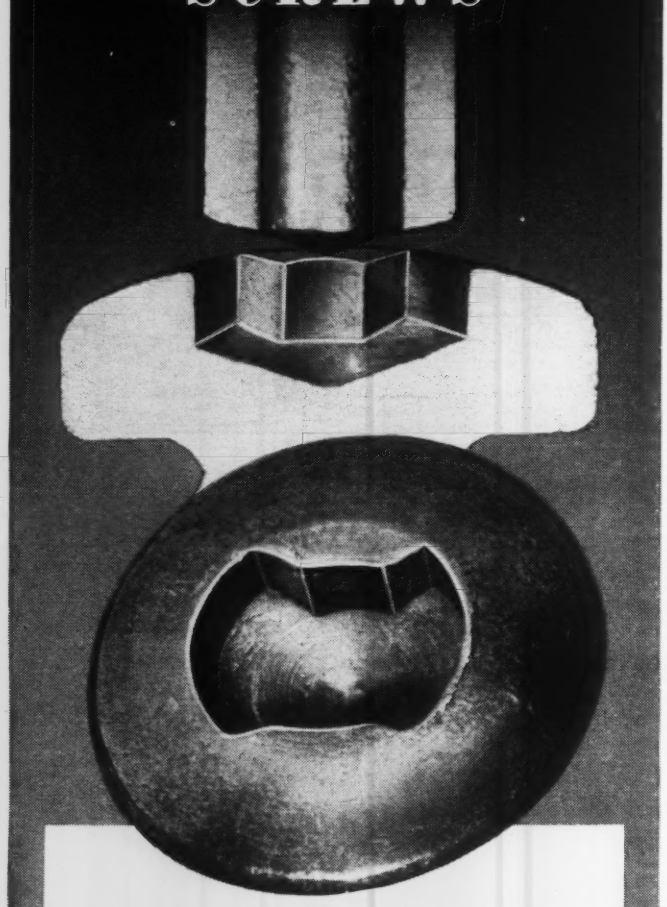
ASK FOR COMPLETE SPECIFICATIONS

No. 96

Specify **POPE** PRECISION SPINDLES

POPE MACHINERY CORPORATION

UNITED CLUTCH HEAD® SCREWS



Driving parallel to the axis of the thread against a straight walled recess, is Clutch Head® screws' claim to superiority over tapered recessed head screws.

—less end pressure
—less ride-out
—reduced screw driver cost
—plus the use of a common screw driver

are the reasons more and more Companies are using Clutch Head screws.

Write for engineering booklet.

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UNITED SCREW and BOLT CORP.
CHICAGO 8, ILL • CLEVELAND 2, OHIO
NEW YORK 7, N. Y.

Men of Machines

the engineering staff is **William Bobek. P. R. Munn Jr.** succeeds Mr. Bobek as chief body draftsman.

♦

Clyde F. Curtis has joined the Lamb Electric Co. as assistant to the president. He was recently associated with Robert Heller and Associates Inc., concerned particularly with fractional-horsepower motors.

♦

Radio Condenser Co., Camden, N. J., has appointed **Joseph S. Robb** as director of engineering in charge of all engineering functions. **Melvin V. Weiss** has been named chief engineer of special apparatus and television, and **Jack Teaf** has been appointed chief engineer of the auto tuner division.

♦

Martial A. Honnell has been elected a vice president and chief engineer of Measurements Corp., Boonton, N. J. He was formerly professor of electrical engineering in charge of communications and electronics at Georgia Institute of Technology.

♦

The Electric Products Co., Cleveland, has appointed **N. F. Diederich** manager of engineering. Mr. Diederich was associated with the Clark Controller Co. for 17 years, serving most recently as manager of engineering standards.

♦

Charles G. Sage has been named president of Arde Associates, Newark, N. J., engineering firm specializing in the design and development of rocket propelled aircraft and heat transfer apparatus. Dr. Sage has been engaged in rocket research since 1941.

♦

The Navy has presented its highest civilian award, the Distinguished Public Service Award, to three research scientists of Hercules Powder Co., Wilmington, Del. **Dr. Lyman G. Bonner,** technical director of the rocket development department at Allegany; **Dr. Ralph F. Preckel,** a research group supervisor; and **Richard Winer,** chief of the rocket development department, received the award for "exceptional contributions to the United States Navy."

♦

Harvey V. Eastling has been appointed general manager of the Pacific Div. of Link-Belt Co., with headquarters in San Francisco. He joined the company in 1925 as chief draftsman at the San Francisco plant and served for a time as chief engineer of the Pacific Div.

♦

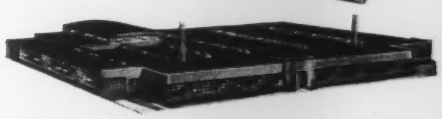
William Miller Instruments Inc., Pasadena, Calif., has appointed **George W. Downs** to the position of vice president and chief engineer; **Raymond C. Olesen,** senior development engineer; **John F. Kalbach,** development engineer; and **Paul A. Dennis,** research engineer.

The manufacturing
of precision gear teeth
at the rate of two miles per day
calls for high speed equipment

AMGEARS HAS IT . . . PLUS

High speed gear shaving
Multiple spindle turning
Multiple spindle honing
High speed gear cutting
High speed tooth chamfering
Multiple spindle
boring machines
Pin point production control
Complete quality
control

TWO MILES OF GEAR TEETH
EVERY DAY



2 BIG PLANTS for gears and gear assemblies

CHICAGO 6633 WEST 65TH STREET, CHICAGO 38
DETROIT 7450 MELVILLE, DETROIT 17

AM ACCURATELY MADE gears, INC.
A SUBSIDIARY OF HUPP CORPORATION

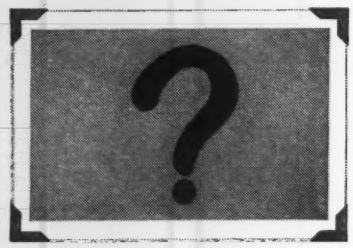
CLEVELAND • DETROIT • CHICAGO

with a customer list that
reads like Who's Who
in American Industry

LOOKING FOR WAYS
TO IMPROVE YOUR PRODUCT?

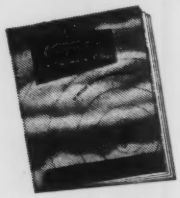
Carpenter FREE-CUT INVAR "36"
is Improving Product Performance
and Reducing Fabricating Costs

How can its unique properties pay off in your own product picture?



The plunger of the syringe shown above is made from Carpenter Free-Cut Invar "36" to assure holding to constant dimensions from room temperatures to sterilizing temperatures. The fitting used for the aircraft instrument was originally made from regular invar. A change to Carpenter Free-Cut Invar "36" still gives the same expansion properties, plus this bonus: elimination of extra operations and bench work in machining . . . output increased 500%!

On a wide range of applications, invar's low coefficient of expansion—ONLY ABOUT 1/10 THAT OF CARBON STEEL UP TO 400°F—has opened the way to improved product performance. And because Carpenter Free-Cut Invar "36" is *free-machining*, you get the advantage of being able to mass produce invar parts faster, more economically, and with vastly improved finishes.



For more information on Carpenter Free-Cut Invar "36", as well as other Carpenter Low Expansion Alloys, write for this free booklet now.

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Export Department: The Carpenter Steel Co., Port Washington, N.Y. "CARSTEELCO"

Carpenter

HIGH NICKEL ALLOYS
offer you new opportunities to design better products.

THE ENGINEER'S Library

Recent Books

Instrument Engineering. *By C. S. Draper, W. McKay, and S. Lees, Massachusetts Institute of Technology; Volume I—285 pages, Volume II—855 pages, 8½ by 11 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, *Volume I—$7.00, Volume II—$15.00 postpaid.*

In Volume I fundamental principles and methods are covered for various instrument engineering situations. A system of measurement and control concepts, notations, diagrams and mathematical forms are developed for describing the performance of physical devices and variations in physical quantities.

Methods for associating mathematical solutions with common forms make up the contents of Volume II. This comprehensive source of information on effective methods and techniques for solving integro-differential equations that commonly appear in descriptions of the behavior of physical systems with "lumped coefficients". Typical results are developed with enough detail to save much routine effort. At the same time attention is called to the place of each example in the general pattern of procedures for finding solutions of typical equations.

♦

Handbook of Probability and Statistics with Tables. *By R. S. Burington and D. C. May; 340 pages, 5¼ by 7¾ inches, clothbound; published by and available from Handbook Publishers Inc., Sandusky, O., $4.50 per copy.*

Theory, working rules and tabular material useful in practical problems in probability and statistics make up the contents of this reference book. Composed of two major sections, the first summarizes the more important formulas and definitions of elementary statistics and probability theory. The other section consists of more than 60 pages of tables of distributions and other quantities of frequent use in statistical work.

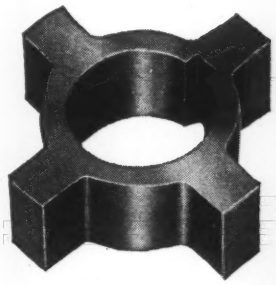
♦

Engineering Electronics. *By G. E. Happell and W. M. Hesselberth, associate professors of electrical engineering, Purdue University; 518 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, *$7.50 postpaid.*

This book covers the fundamentals of electronics

GRAMIX® sintered metal parts

- save material, machining time and money
- cost less in production quantities
- can be oil impregnated for self lubrication
- improve product performance



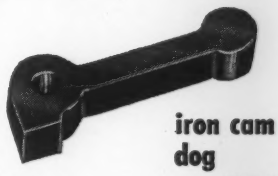
iron clutch spider 13½¢

bronze cam 6¢

iron planetary gear 25½c

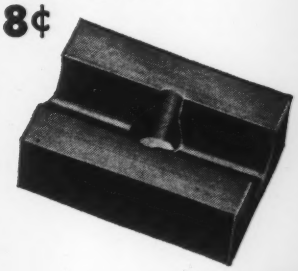
bronze spacer 5¢

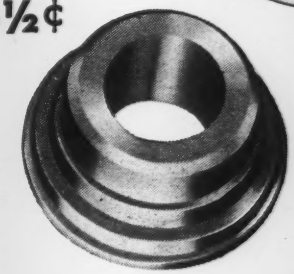
iron idler roller 36¢



iron cam dog 4½¢

iron spacer block 8¢



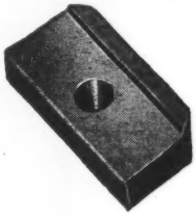


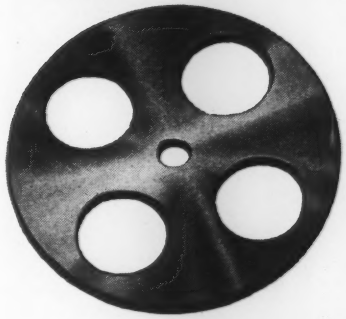
iron rod guide 14½¢

bronze contact shoe 7½¢

5¢ iron sheave

iron arm regulator 2¢





iron cam 8½¢

7¢ iron nut

iron gear blank 12¢

100

100TH YEAR . . .

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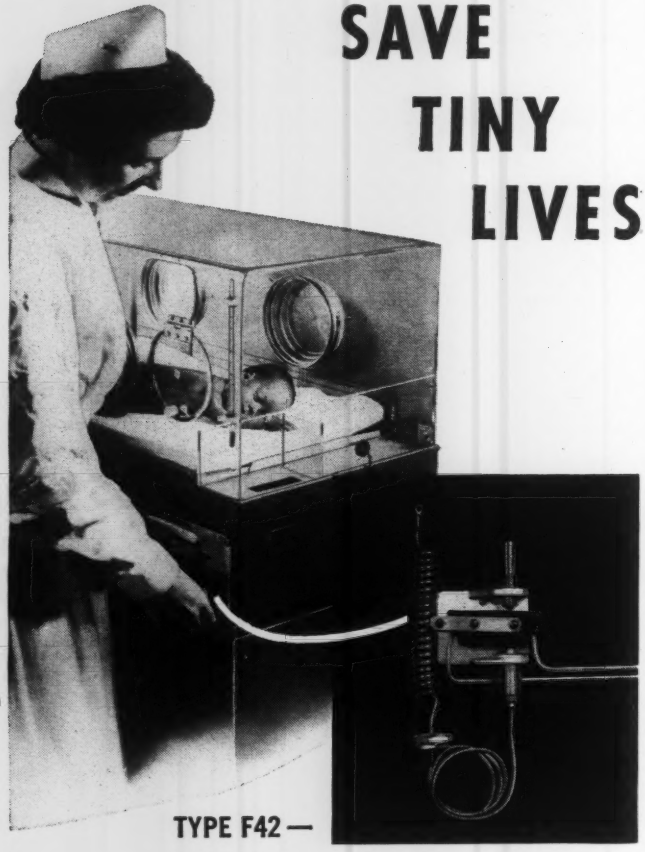
UE TEMPERATURE CONTROLS ... HELP ISOLETTE® INCUBATORS SAVE TINY LIVES



TYPE F42 —

UE controls are used in many notable applications — but none serves a more vital function than the Type F42 Thermostat now being used in Isolette Infant Incubators.

Isolette incubators feature extremely uniform air conditioning with or without added oxygen. With a basic sensitivity of ±1°F within the operating range of 75–100°F, the F42 enables these units to maintain a maximum temperature difference across the mattress of ±2°F surpassing Children's Bureau Specifications. The Type F42 achieves this control by switching on or off a 250 watt heating element located in a passage of the air circulation system.

United Electric manufactures a wide line of standard controls. They are being used for controlling aircraft fuel purging systems, paper mill machinery, diesel engines, milk pasteurizers and room air conditioners. And these are but a few of the hundreds of different industrial and domestic applications where UE controls are on the job.

Special controls can either be adapted from standard models, or they can be custom-built by United engineers working in cooperation with your own product development engineers.

For additional information on the Type F42 — or the complete line of United Electric controls and their countless applications — write:

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The Engineer's Library

from both theoretical and practical standpoints. Intended to be a textbook for use in a beginning course in electronics for engineering students, the book assumes a knowledge of physics, calculus, and dc circuits. A brief study of the physics of vacuum tubes is made in the first four chapters followed by a description of circuits and actions of some common electronic devices in Chapter 5. Concepts useful in vacuum tube circuit analysis comprise Chapter 6. The remaining ten chapters embrace various aspects of electronics such as amplifiers, oscillators, rectifiers, photoelectric cells, and semiconductor theory.

♦

Engineering Formulas & Tables. 350 *pages, multiple ring binder with twelve* 3¾ *by* 6¾*-inch paperbound sections; available from Lefax Publishers, 9th & Sansom St., Philadelphia* 7, *Pa.,* $2.75.

Basic formulas, design data, and tables useful in engineering are included in this pocket-size data book. The twelve sections are tabbed: mathematics; measures; materials; gages, screws, etc.; mechanics; electricity and magnetism; hydraulics; structural data, reinforced concrete; pipe and fittings; steam tables; and mathematical tables.

New Standards

Knurling. *ASA B*5.30-1953; 15 *pages,* 8½ *by* 11 *inches, paperbound; available from American Society of Mechanical Engineers,* 29 *W.* 39*th St., New York* 18, *N. Y.,* $1.00 *per copy.*

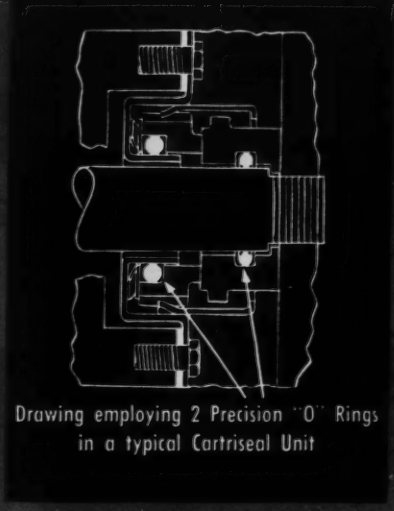
This standard covers knurling tools with standardized diametral pitches and includes dimensional relations with stock in the production of straight, diagonal or diamond knurling applied to cylindrical surfaces. Material covers knurling having teeth of uniform pitch parallel to cylinder axis or at a helix angle not exceeding an angle of 45 degrees with axis of work.

Government Publications

Frictional Behavior of Polyethylene, Polytetrafluoroethylene, and Halogenated Derivatives. *By R. C. Bowers, W. C. Clinton and W. A. Zisman, Chemistry Div., Naval Research Laboratory;* 23 *pages,* 8 *x* 10½ *inches, paperbound; available from U. S. Dept. of Commerce, Business and Defense Services Administration, Office of Technical Services, Washington* 25, *D. C.,* 75 *cents per copy.*

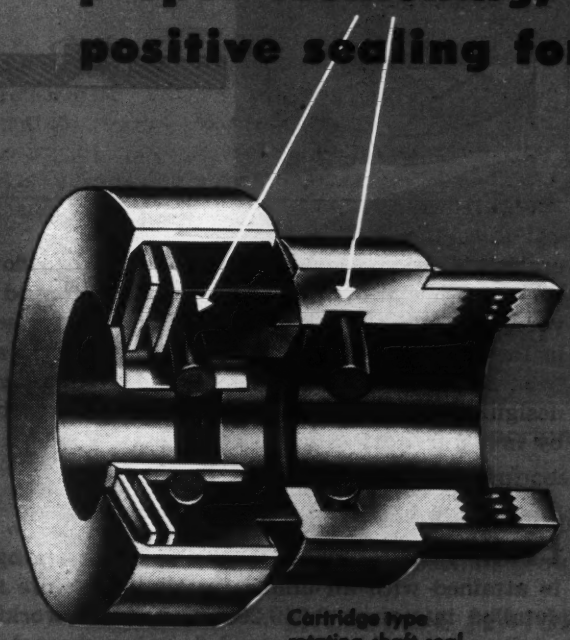
An evaluation of frictional losses in high polymers is made in this research report. Friction and wear studies of TFE, polyethylene, and polyvinyl chloride are confirmed along with data on other plastics. Some new generalizations are given concerning relations of chemical constitution to friction and new data on lubricating properties of thin plastic films.

Precision "O" Rings assure



Drawing employing 2 Precision "O" Rings in a typical Cartriseal Unit

proper cushioning, perfect performance, positive sealing for CARTRISEAL UNITS



Cartridge type rotating shaft seal

Compact, dependable cartridge type sealing units, made by Cartriseal Corp. of Chicago, replace bulky, old-fashioned packing rings and solve many rotating shaft sealing problems. In order to assure highest quality and positive, leak-proof service, Cartriseal engineers specify Precision "O" Rings for these hydraulically balanced, easy-to-install units!

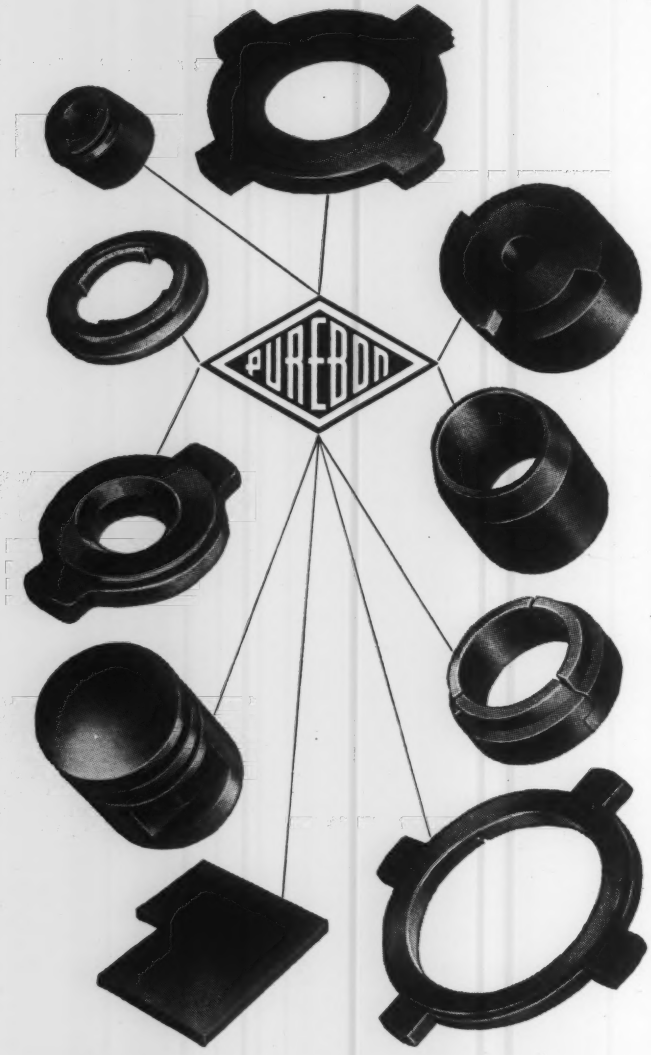
Everyone is finding Precision "O" Rings the best answer to many sealing problems—and they are finding, too, that Precision leads the field in engineering help. Let us help you. Send for our "O" Ring Handbook and let us have your inquiries.

FREE—Write for your personal copy of our Handbook on "O" Rings.

Precision Rubber Products CORPORATION

"O" Ring and Dyna-seal Specialists ®

Box 431, Dayton 1, Ohio • Canadian Plant at: St. Thérèse de Blainville, Québec



Purebon

SOLVES MANY PROBLEMS
caused by sliding or rotating parts which are DIFFICULT OR IMPOSSIBLE TO LUBRICATE

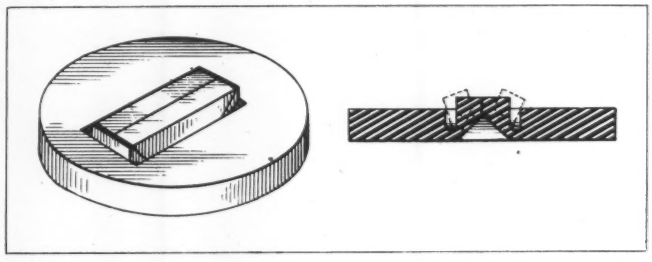
A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machinable and in many cases can be molded directly to size.

Bulletin No. 52 tells the complete story of Purebon.
Write for your copy today.

PURE CARBON CO., INC.
446 HALL AVE. **ST. MARYS, PA.**

NOTEWORTHY Patents

ONE-WAY FLOW CONTROL for hydraulic systems is provided by a novel check valve design employing a one-piece molded rubber construction. Described in patent 2,644,663, the valve is designed for insertion into a fluid line and consists of a rubber disk with two molded rectangular flaps or lips which control flow through a central opening in the disk. Valve operation is automatic, the flaps opening when flow is in one direction and closing when flow is stopped or reversed. Fluid pressure acts to lock the flaps securely in the closed position, assuring a positive seal against back flow. Production is facilitated by this simplified design which has been assigned to Roth Rubber Co. by inventor Karl A. Klingler.



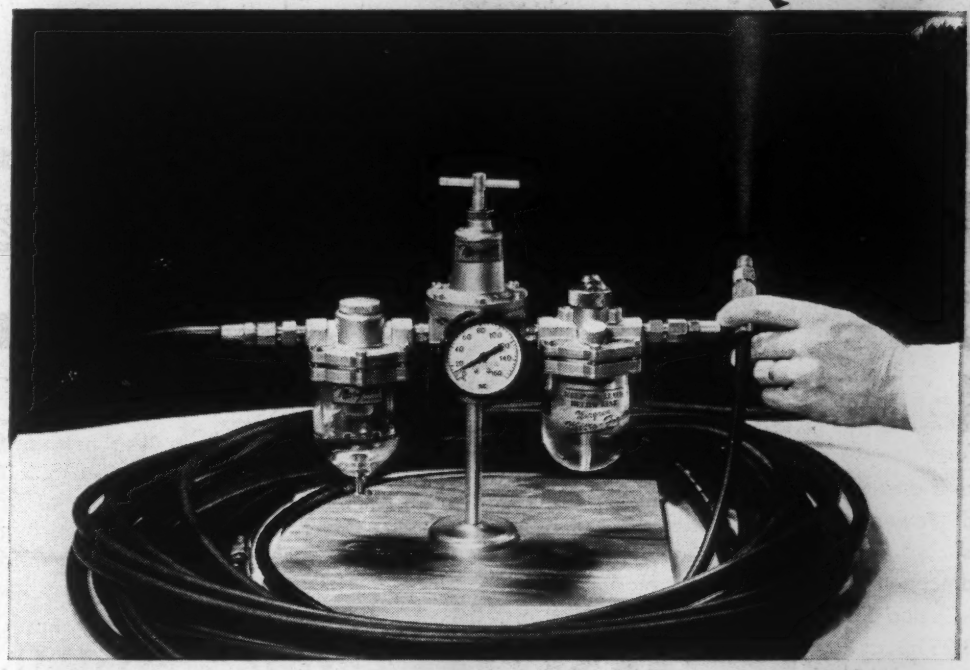
HIGH ENERGY ABSORPTION under spring loads is attained with an unusual design of volute springs detailed in patent 2,649,298. Increased working capacities, as well as improved damping characteristics, are obtained by employing coils under frictional contact and wound at a "negative" helix angle. Results of comparative tests indicate that for small deflections energy capacities with the new design may run as much as four times greater than for conventional types. Two types of constructions for application as either a snubber or a nonharmonic load spring are covered in the patent which has been assigned to Holland Co. by Cal W. Wulff and Frank G. Newman.

MECHANICAL FRICTION CONTROL facilitates engagement and release in a clutch design detailed in patent 2,641,345. Assigned to Twin Disc Clutch Co., the design employs a novel lever system to control the engagement of two sliding clutch plates, mounted to the driven shaft, with a friction disk which rotates between the plates and is connected to the power source. Key elements in the clutch operating mechanism are a number of hook shaped levers which are mounted in slots with the hook

tests prove

NORGREN MICRO-FOG

delivers lubricating fog after traveling thru 130 ft. of hose



One of the many important advantages of Norgren Micro-Fog is its ability to travel longer distances... a feature which assures absolutely uniform distribution of lubricant through as many as 40 outlets. This reduces lubrication costs and permits greater flexibility in product design and plant layout.

EXCLUSIVE FEATURES OF NORGREN MICRO-FOG LUBRICATORS FOR SMALL AIR-OPERATED DEVICES

VISIBLE OIL FEED CONSTANT OIL LEVEL

Rate of feed is not affected by oil supply.

OIL FEED CONTROLLED BY AIR

Gives accurate control and uniform rate of feed.

WRITE FOR NEW CATALOG No. 600

Vitalizer Unit for tools, cylinders, etc.

Micro-Fog Lubro-Control Unit for bearings, spindles, gear boxes.

Micro-Fog Lubro-Control Unit for tools and cylinders requiring regulated air pressure.

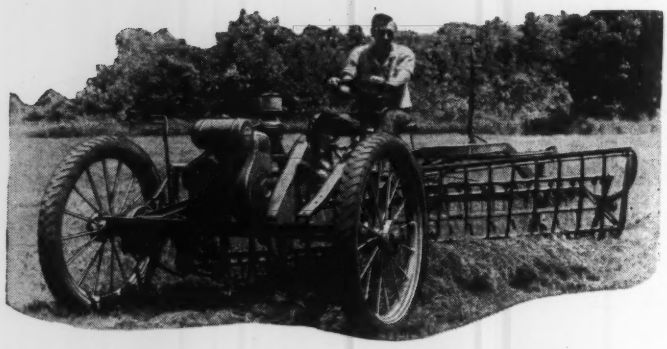
Micro-Fog Lubricator, tank type, 1¾ gal. cap.

PIONEER AND LEADER IN OIL FOG LUBRICATION FOR **26** YEARS

C. A. Norgren CO.

3442 So. Elati, Englewood, Colo.

VALVES — FILTERS — REGULATORS — LUBRICATORS — HOSE ASSEMBLIES



Another Farm Job Simplified... WISCONSIN-POWERED Side Delivery Rake

Power TO FIT THE JOB

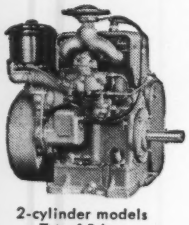
Power TO FIT THE MACHINE

Here is an interesting example of "Power to Fit the Job" and "Power to Fit the Machine" . . . without power waste, yet maintaining maximum operating efficiency and economy. A single cylinder Model AEN Wisconsin Air-Cooled Engine, rated from 4.5 hp. at 1600 rpm. to 8.25 hp. at 3600 rpm., carries the entire load. Front-end mounting of engine (weight 110 lbs.) provides adequate traction.

This new idea in windrowing hay with a side delivery rake is a development of D. W. Lee Implement Co., Russellville, Ark.

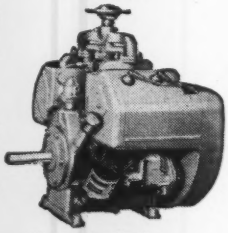
4-cycle single cylinder 3 to 9 hp.

Because of their extremely compact design, relatively light weight, and availability in a complete power range from 3 to 36 hp., in single cylinder, 2- and V-type 4-cylinder models, Wisconsin Heavy-Duty Air-Cooled Engines offer the power equipment manufacturer a choice of power units for original equipment installation without costly re-designing of the machine itself.



2-cylinder models 7 to 15 hp.

If you are not completely familiar with Wisconsin Air-Cooled Engines, write for your copy of our latest catalog.



V-type 4-cylinder, 15 to 36 hp.

WISCONSIN MOTOR CORPORATION

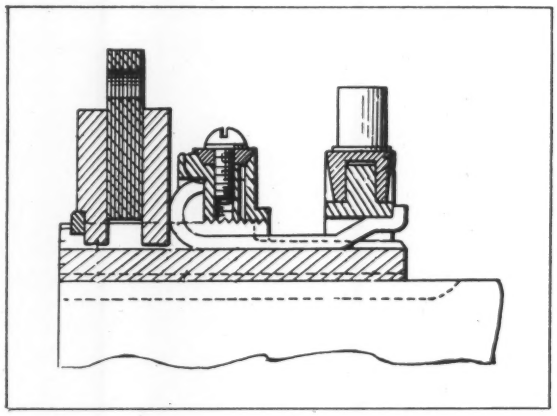
World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 7559-½

Noteworthy Patents

bearing against the back of one of the clutch plates. Lever position is maintained by an adjusting ring which bears against the hook ends and serves as a fulcrum. Depression of the levers at their free ends by means of a sliding collar produces a wedging action, clamping the clutch plates against the friction disk. Positive engagement is assured by locking of



the device in the driving position; positive release is provided by centrifugal force. Service adjustment of clamping pressure to provide takeup for wear is readily accomplished through the adjusting ring without disassembly. Two modified constructions are also shown in the patent which has been assigned by Henry J. Dunkelow.

DIRECTIONAL FLOW CONTROL in hydraulic lines serving dual functions of high-pressure supply and low-pressure return is provided by a single-mounted valve unit assigned to Hydraulic Research & Mfg. Co. Inc. Described in patent 2,645,242, the valve operates automatically in response to pressure and flow direction. Operating pressures of the order of 1500 psi for the high-pressure side and 5 or 10 psi for the low-pressure side are typical. High-pressure flow is controlled by a cylindrical spring-loaded plunger, low-pressure flow by a spring-loaded poppet. In operation, high-pressure fluid actuates the plunger to open ports which bypass flow around the closed poppet and through the valve. For reverse flow at low pressure, the plunger closes off the bypass ports and the poppet opens, permitting fluid to pass through the center of the plunger and out of the valve. A particularly useful application of the valve is for "priority" control of flow to four-way valves; flow is prevented from passing to the four-way valve until other more essential components have been supplied and sufficient system pressure has been built up. Carl E. Monich is the inventor.

Copies of the patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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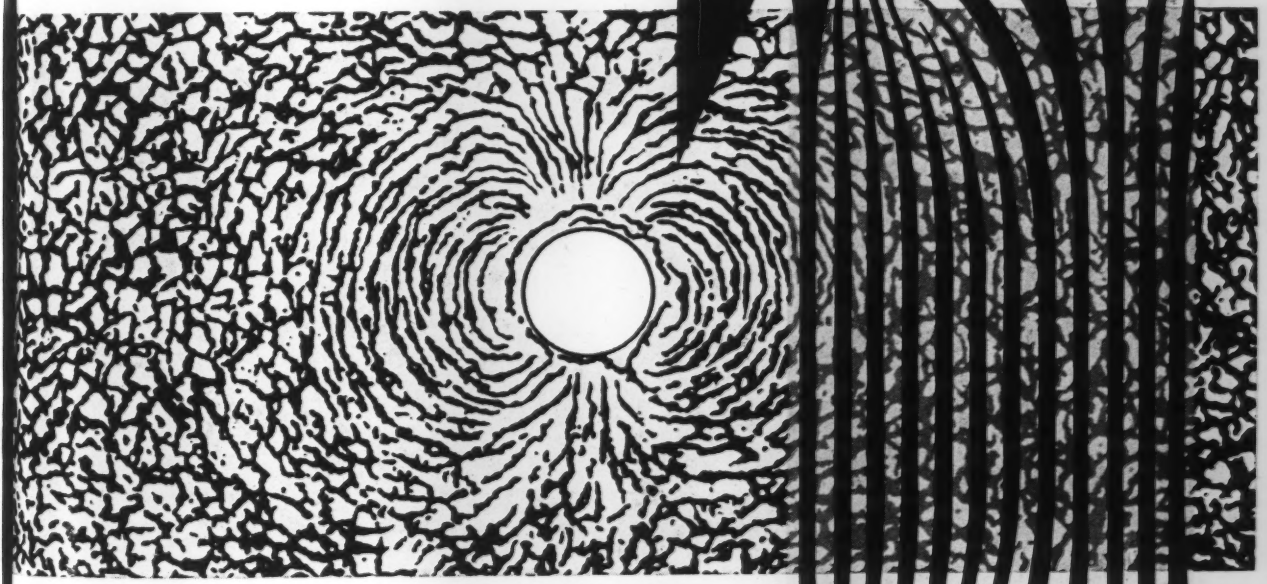
MACHINE DESIGN

March 1954



STRESS ANALYSIS IN DESIGN

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ALLIS-CHALMERS

PUMPS for Designers

3 Ways to Save

1

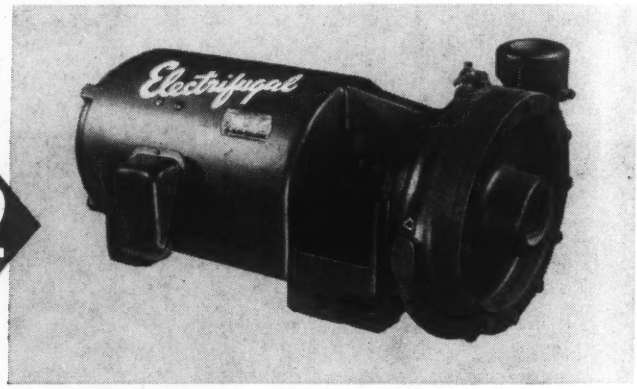
SAVE ENGINEERING TIME

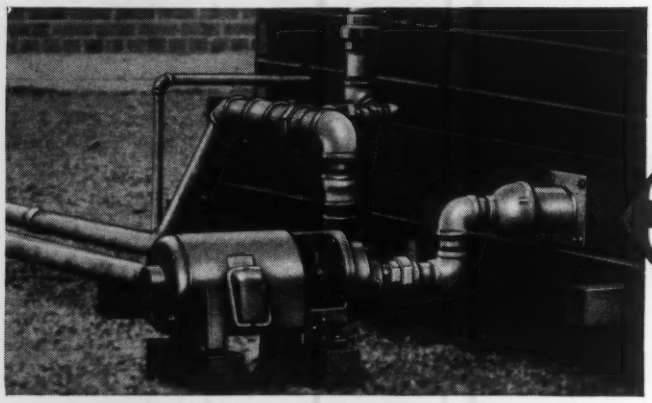
Allis-Chalmers representative will sit down with you in the planning stage and help you design the best possible pump set-up at the lowest cost. A-C field engineers will save you much costly engineering work and *guarantee* the complete pump and motor unit.

SAVE—NO EXTRA PARTS TO BUY

Designed as a complete, compact unit, Allis-Chalmers close-coupled pumps don't require extras — such as couplings, bases or shims. The pumps come as units ready to hook up and run!

2





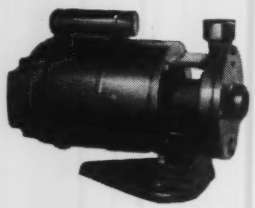
3

SAVE ON INSTALLATION TIME

Bolt it down, hook up the line and piping, and your Allis-Chalmers pump is ready to go. There's no alignment problem. Correct installation is a big factor in pump performance and the A-C engineer will advise you at this point.

For more information about Allis-Chalmers designers' pumps, write for bulletins 52B6140, 52B7529, 52B6083 or 52B6975.

ALLIS-CHALMERS, Milwaukee 1, Wisconsin



FHP PACKAGE PUMP

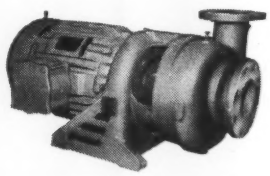
Standard with mechanical seal. Widely used and accepted for air conditioning and refrigeration.

Bulletin 52B7529

***ELECTRIFUGAL* PUMP**

A close-coupled pump with either conventional packing or mechanical seal.

Bulletin 52B6140



SUPPORTING ADAPTER PUMP

Flange motor and pump on sturdy supporting adapter. With conventional packing or mechanical seal.

Bulletin 52B6083

VERTICAL MOUNTED PUMP

Mechanical seal or sealless units with choice of submerged or sidewall mounting.

Bulletin 52B6975

Electrifugal is an Allis-Chalmers trademark.

ALLIS-CHALMERS

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A-4228

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FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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Over the Board

John Holt

A new name appears on our masthead (the left-hand column on Page 3) this month—that of John Holt, assistant editor, whose picture appears on Page 321. He is one of the additions to the editorial staff made necessary by the transfer of Roger Bolz to *Automation*. An engineering graduate of Case Institute of Technology (1951), John comes to us from the Chesapeake & Ohio Railway where he was a design engineer in the research department. During his period of service with the army he was stationed in India, where he worked on maintenance of railroad mechanical equipment. A lifelong enthusiasm for railroading finds continuing satisfaction in his membership in the National Railway Historical Society and the Federation for Railway Progress, and in his daily commuting—on the Erie Railroad—to Cleveland. Like his colleague Bob Rodgers, John seems to the rest of us ordinary mortals to be bumping his head against the stratosphere—a six-footer plus.

This Month's Cover

Stress analysis, once regarded as the epitome of theoretical activity, has long since reached a highly practical plane, due in large part to the contributions of experimental stress analysts. With stress distributions beautifully pictured through such techniques as photoelasticity and brittle coatings, the practical engineer can see with his own eyes how his designs are likely to perform in service. Hartman and Benner's 4-part series of articles, commencing in this issue (Page 134), present a comprehensive view of how theoretical and experimental methods complement each other in practical design. To highlight the subject on this month's front cover, George Farnsworth has illustrated the photoelastic stress pattern in one typical load situation and the brittle coating pattern in another.

The Stork Is Coming

We're expecting an addition to the Penton family this year. Our baby sister is to be named *Automation* and the obstetricians will be Roger W. Bolz and Edward S. Lawson. Roger (see Page 318) will be editor of the new publication and Ed, formerly New England district manager of MACHINE DESIGN, will be business manager. Inasmuch as no existing publication, including MACHINE DESIGN, has space to do full justice to the specific needs of the automation field—the science of automatic production — the new magazine will fill in a unique manner a rapidly growing demand. Incidentally, although Roger will no longer be active on the editorial staff of MACHINE DESIGN, you will still see his name listed on our masthead as contributing editor and, from time to time, as author of articles in our pages.

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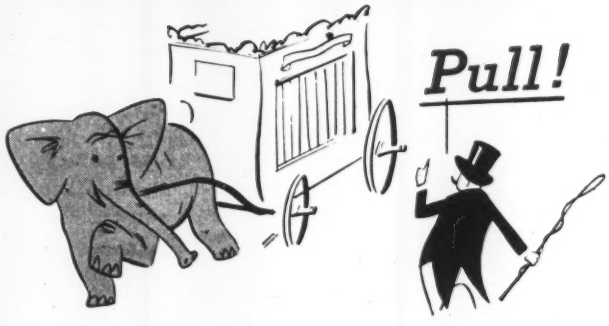
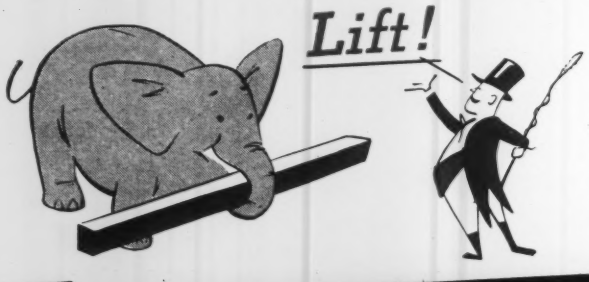
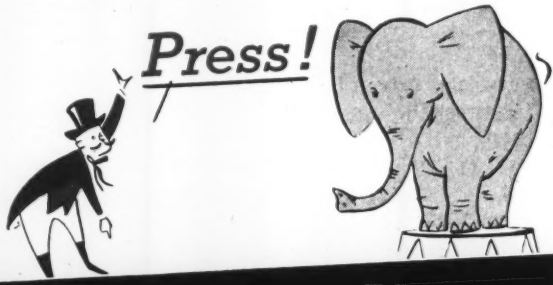
get controlled POWER







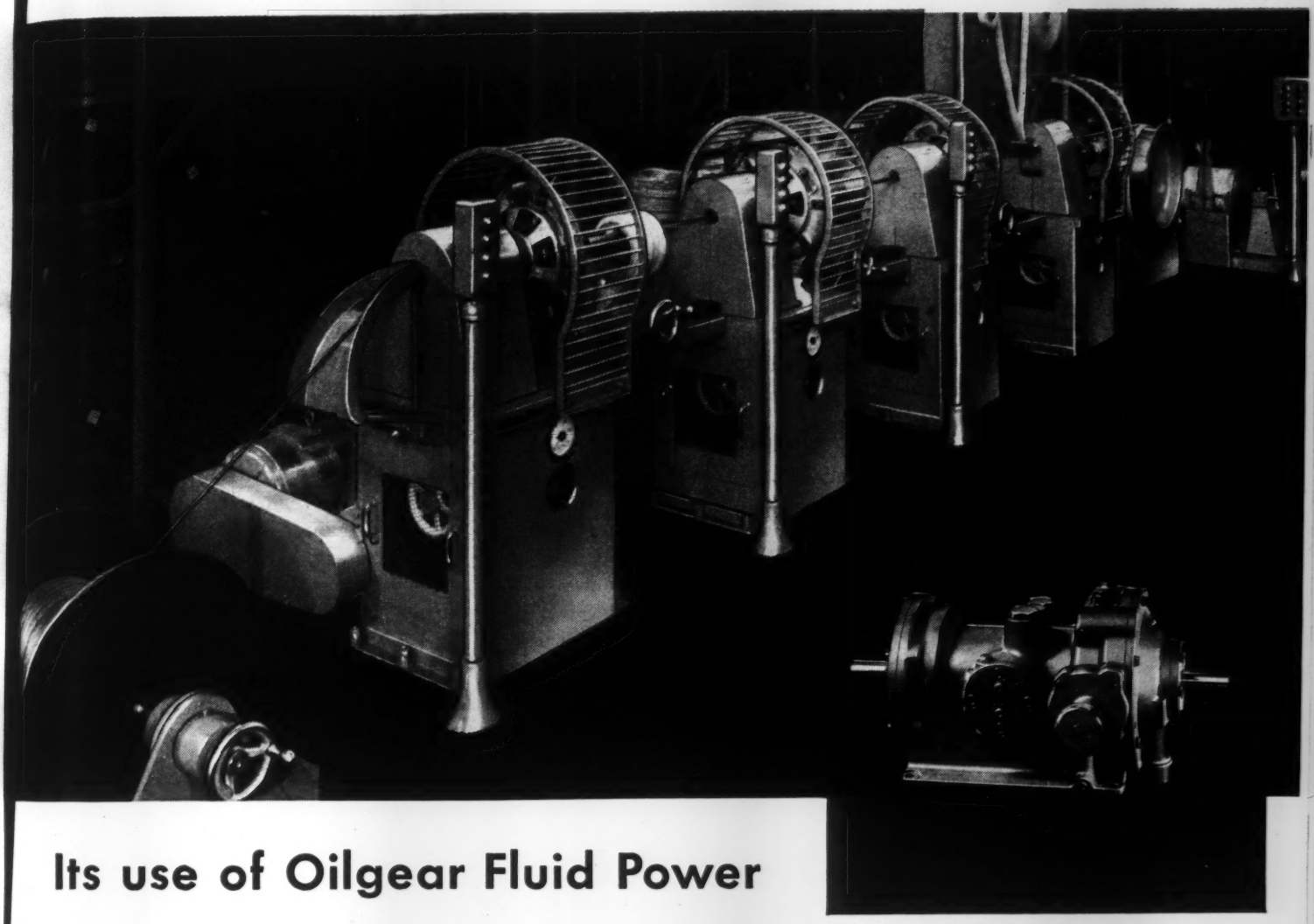
with Hanna L-P Cylinders
LOW PRESSURE

All the power in the universe is of no use to anyone unless it's controlled. Hanna L-P Fluid Power Cylinders provide simplified, precision control of power ranging from a few pounds to fifteen tons. Their exclusive design and construction features assure dependable control of power that's carefully matched to the motion required. These sturdy cylinders are available in a variety of standard mounting styles to meet specific requirements. Note the exclusive Hanna features that contribute to their superior performance. Better still, refer your power motion problems to a Hanna engineer. You'll find him listed in your local classified telephone directory. And you'll find him well qualified to help solve your problems economically and efficiently.

CONTROLLED POWER HANNA FEATURES:

- Cup-type piston packings are synthetic impregnated leather for maximum flexibility with minimum porosity. Spring-backed to assure uniform contact with tube. Packings are chrome-tanned to provide smooth finish and minimize friction.

MACHINE DESIGN AT WESTERN ELECTRIC



Its use of Oilgear Fluid Power

Western Electric Company, manufacturing unit of the Bell Telephone System, originates, designs and builds many of the special machines it uses in its own manufacturing processes. It also maintains unceasing pressure to improve upon machines already in operation, for optimum performance, for better product, for lower costs, for freedom from trouble.

Its use of Oilgear Fluid Power Drives and Transmissions has been increasing because, in the words of their engineers, Oilgear enables them among other things to synperformance, the speed of the heads should be easily and independently variable and the direction of rotation instantly changeable because the lay and pitch of the wrappings must be varied according to the requirements of the run. Moreover, the inside contour of the tube formed by the wrapping should be smooth and uniform so as to avoid setting up echo waves that interfere with transmission and vitiate signal strength.

Because of these requirements, a new drive was installed something over 4 years ago. A line [illegible] drives five Oilgear Fluid Power Transmis-

The results were these: uniformity and control of tension are so good, the machine runs at 4 times its former machine speed; it is easy to vary speed and direction of rotation of each individual head; eccentric heads gave way to concentric heads, and supply spools are now loaded to full capacity instead of ¼th to ⅛th as before; the machine is stopped less frequently for loading. Maintenance on the former drive was involved and frequent—on the Oilgear equipment it has been simple and negligible.

There is some reason to suspect